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Published by the

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VOL. XVIII MAY, 1931 No. 5

EDITORIAL

The Review—*Past, Present and Future*

The first issue of the MONTHLY REVIEW was published in June, 1913. Mr. Samuel R. Taylor was the editor. The first year's numbers contained 54 pages and were only published quarterly, but since that time the REVIEW has been printed regularly every month. The following editors have served:

H. E. Wilmore,	1914-1915
J. H. Hansjosten,	1915-1916
H. J. Richards,	1916-1917
H. H. Williams,	1917-1921
W. J. Allen,	1921-1922
F. C. Mesle,	1922-1926
F. J. Hanlon,	1926-1930

Each year has seen the REVIEW improve. It has been a most important factor in making the American Electro-Platers Society a vital force in the industrial world. Keeping in close touch as it does with the most recent developments in industry and science, it is eagerly sought after, not only by the members of the A. E. S., but by manufacturers, public libraries, various branches of the government, schools and colleges, both in this country and abroad. Quite frequently letters have been received from England, Germany, Italy, Japan, Canada and Australia, asking that certain numbers be mailed; in several instances the writers wish to be placed on our

mailing list, stating that they are most desirous of keeping their files intact.

Starting as it did with a humble origin, there are now over sixteen hundred copies mailed each month. With new branches (we now have twenty-seven, including Anderson, Ind., and San Francisco, Calif.) it is reasonable to predict that in a year or two our mailing list should contain over two thousand subscribers.

In view of these encouraging prospects, it would seem advisable to devote a little time to discuss the future policies of the REVIEW at the Rochester Convention that we may hear from the assembled delegates their ideas regarding ways and means of making this publication a more potent factor in the building up of our organization and in being a still greater help to the readers of the REVIEW who find both profit and pleasure in scanning its pages and contributing to its support.

The sole object of this article is to stir up the minds of our readers regarding this publication of ours. We may wish to make some radical changes, and depart from former methods in its make-up, but our aim must be the advancement of our Society, and it seems as though the REVIEW must take a very prominent part, now and in years to come, as it has in the past, to place the American Electro-Platers Society where it rightfully belongs—the leader of all such organizations.

ANODE RODS

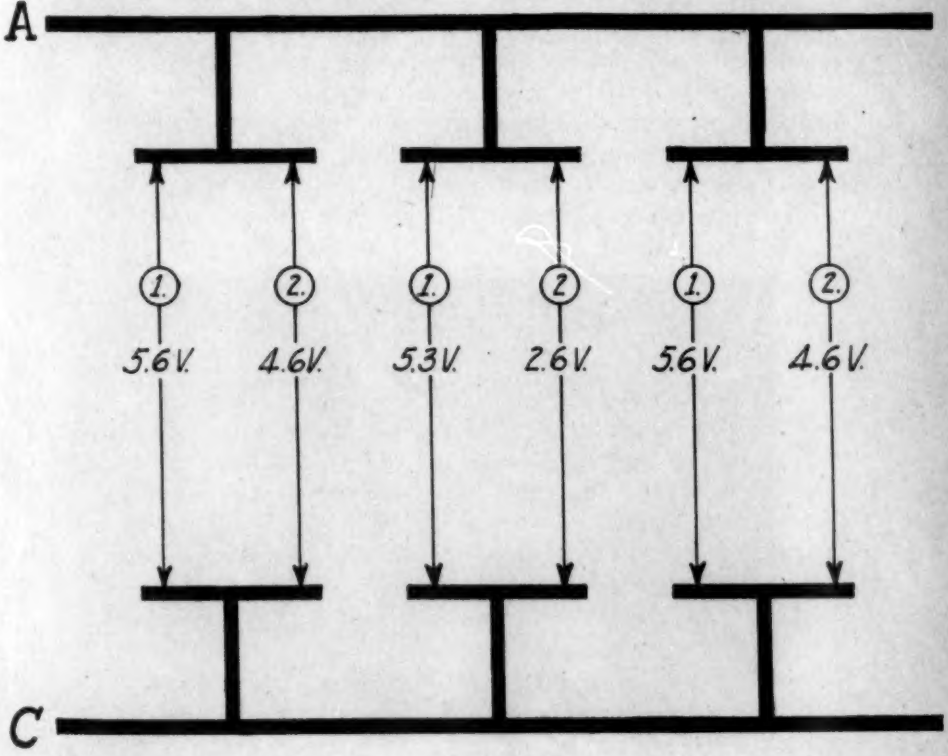
By George B. Hogaboom

Every precaution possible is taken to have work clean before it goes into a plating solution. The cathode bars are kept clean so that there will be a perfect contact to obtain the full value of the current flowing and to prevent light deposits or peeling. This is as it should be, but how about the anode rods? I have seen anode rods so heavily coated with crystallized or evaporated solution that had it not been for the knife edge of the anode hook there would have been little or no contact between the anode and the anode rod.

It is common practice to permit solution to drip onto the anode rods when work is being removed from the solution. It is overlooked that the solution will get between the hook and the anode rod and when the salts become dry that they will act as an insulator. If it is important to keep the contacts to the cathode rods clean, it is

of equal importance to keep the anode rods clean. Insulation or partial insulation means a loss of anode efficiency unless a greater pressure is used.

The tank voltmeter may register the resistance of the whole tank, and the indicated voltage is taken as voltage used in plating. This will be misleading if all the rod and work contacts are not clean. A different voltage will be had between an anode that hangs on an unclean spot on the anode rod and the cathode rod than between the cathode rod and an anode having a clean contact. There will be a voltage drop between the two anodes and this will result in the anode having the lower voltage receiving a deposit of metal. This condition will affect both the anode and the cathode efficiency. The anode will not give up the amount of metal it should and the work directly in front of such an anode will have a lighter deposit of metal than the work in front of an anode having a clean contact.



The character of the anode corrosion is changed and this oftentimes explains why one anode corrodes better in a solution than another.

In one plant it was noticed that some of the nickel anodes had a heavy "skin" formed on them even when more than half of their weight had gone into solution. Of course the metal in the anode was to blame! The anode rods, however, were encrusted with crystallized salts; when the hook was lifted, only a faint trace of bright copper on the anode rod could be seen. The anode was replaced and with a portable voltmeter measurements were made between the several anodes and the cathode rod. There was a difference of 2 volts between pressure recorded from the anodes on either side of it which had clean contact. The condition existing is shown in the diagram on page 5.

If a completely insulated anode was hung between two active anodes, the current from the active anodes would pass through the insulated anode; it would go in one side and pass out the other. It is reasonable to assume that if there is a partial insulation the same thing will be true. There is a drop of potential between the anodes and the one having the lower potential will act as an intermediate electrode. In the series refining of copper where one side of the copper electrode is the anode and the other side the cathode —a bi-polar electrode—there is a voltage drop of only 0.2 volts.

To prove this a tank containing 40 gallons of nickel solution was set up. Three anodes were placed on the middle rod and on the two

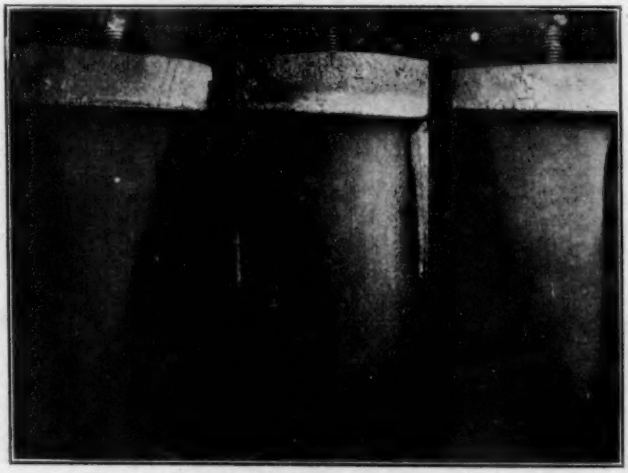


FIGURE 1

outside rods were placed cathodes having an area equal to that of the anodes. The center anode hook was completely insulated from the anode rod. One end of a piece of resistance wire was connected to the anode rod and the other to the hook of the middle anode. Between the two outside anodes and the cathode there was a pressure of 5.6 volts; between the center anode a pressure of 5.3 volts. Within 24 hours the center anode showed evidence of receiving a deposit on the side next to the tank from which it was separated by 6 inches. This was permitted to increase until it was heavy enough to photograph (see Figure 1).

The center anode was replaced by a new one and the resistance was increased so that there was a difference of 2 volts between the center anode and the outside anodes and the cathodes. This run was continued for several days, with the result that a very heavy deposit was had on the center anode. During the run the current at three different times was shut off for several hours. This caused three distinct layers of nickel deposit, as can be seen in Figure 3. Figure 2 shows the front of the anode, that is, the side toward the cathode, and Figure 3 the back of the anode which faced the tank. The anodes on either side of the center anode were of the same size as the center anode at the start of the run. This clearly indicates that the center anode had a low efficiency and that the work in front of it received a light deposit.

FIGURE 2

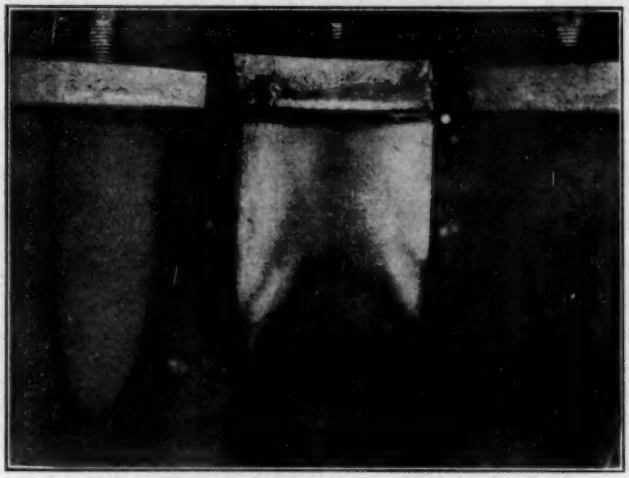


FIGURE 3

Although no runs were made, it is reasonable to predict that the same phenomenon will occur if anodes of different purity or of different physical characteristics are run alongside one another. Just as much care should be exercised in keeping anode rods clean and the conditions uniform on the anode side of the tank as that always given to the cathode side. It is only from a well balanced, carefully controlled plating installation that consistently good results can be expected.

THROWING POWER OF SULFATE ZINC BATH

By L. C. Pan

Paper presented at the Annual Educational Session of the New York Branch, American Electro-Platers' Society, February 21, 1931

For zinc plating, we have in common use two types of bath. One is the cyanide and the other is the sulfate bath, commonly called acid zinc bath.

While these two baths are equally extensively used they are essentially different in their operating qualities. In most cases, the choice of one or the other depends upon the type of work to be zinc plated, and also upon the volume of work to be done in a single shop. In order to make an intelligent choice of the two baths, we have to know the advantages and disadvantages of each.

Among the advantages of the sulfate over the cyanide bath, the important ones are:

1. Purity of the deposit.
2. High cathode efficiency.
3. Low maintenance cost.
4. Denser and brighter deposit.
5. It can be used more satisfactorily in plating cast iron articles.
6. Solution not injurious to tanks and barrels of ordinary construction.

Due to the high position of zinc in the electromotive series, it will precipitate any metallic impurity from the sulfate solution, with the result that after the few hours of operation the solution contains practically no metallic impurities such as copper, lead, tin, etc., which would otherwise be deposited with zinc onto the work and materially decrease the protective value of the zinc coating. Since the solution under operation is thus free from metals more positive than zinc, there is no possibility of these metals being deposited with zinc. And the purer the zinc deposit the more resistant to corrosion it is, and therefore the longer is the life of the coating.

Due to the fact that metals in the lower part of the electromotive series are continually precipitated out by displacement at the anode, the solution becomes sometimes full of suspended matter. This is objectionable if plating is to be carried out in a barrel or in an agitated tank. Therefore, under such conditions, a continuous filtering operation is provided alongside the plating operation.

When the sulfate bath is operated at the proper acidity, the cathode efficiency is practically 100%, which means that there is no loss of power in operating the sulfate zinc bath and a given size generator will turn out more work. When cathode efficiency is high there is less occluded hydrogen gas in the deposit, which makes the zinc coating less porous and more resistant to chemical attacks of chemical or atmospheric elements.

Not only the cathode efficiency from the sulfate zinc bath is high, but the anode efficiency is even higher than that of the cathode efficiency. This is really an ideal condition for a plating operation. The excess anode efficiency will replace the loss of metal through dragout and other mechanical handling involved in the plating operation. This makes it possible to operate the still tank with practically no constant additions of zinc salts which is necessary in the case of the cyanide bath.

Zinc salts are more expensive than zinc metal in the form of anodes. A solution which is capable of maintaining its metal content by drawing metal from the anodes will save money equal to the difference between the price of the metal in the form of salts and the price of the metal in the form of anodes. In barrel plating, however, the loss through dragout is so much that it is impossible to depend on excess anode efficiency to maintain the metal content of the bath, and chemicals, especially metal salts, have to be added constantly. This is true also in the case of the cyanide bath, but since zinc cyanide is much more expensive than zinc sulfate the cost of replacing metal loss through dragout is many times greater for the cyanide bath than it is for the sulfate bath.

Although usually zinc plating is not for the appearance of the article, yet the smoothness and brightness of the zinc deposit from a sulfate bath is a decided advantage in that less metal will be required for the same protection if the zinc deposit is dense and bright. Bright deposits usually are less absorbent of moisture and therefore more resistant to corrosion. In many cases, however, a smooth and bright deposit is demanded, and if the cyanide zinc bath is used an extra operation of buffing will be involved, which means more expense in the making of the zinc coating.

For rust-proofing and cast iron articles, the sulfate bath should be used because the cyanide bath might give rise to blisters and poor adherence unless some special addition agent, such as mercury, is used.

In barrel plating, certain parts of the machinery in contact with the plating solution have to be non-conductors of electricity and at the same time possess high strength. Ordinarily, such parts are made of materials like wood, celluloid and bakelite. These materials are all right for sulfate zinc solutions. When barrel plating in cyanide bath is desired, these materials fail under the strong caustic action of the cyanide bath. The only thing left to use would be rubber. But rubber has not sufficient strength to be self-supporting, and reinforcing makes the machine parts clumsy and repair costs high.

All the above points are the advantages of the zinc bath against the cyanide bath, but there are also disadvantages about the sulfate bath. The first one is the low throwing power, and the second one is the low conductivity of the sulfate solution.

The throwing power of the sulfate bath is notably lower than the

cyanide zinc bath. For articles that have deep recesses, it is difficult to give a uniform coating throughout the entire surface from the sulfate bath. Low conductivity means higher voltage required to do the plating and therefore higher power cost.

Taking into consideration both the advantages and the disadvantages of the two processes for zinc plating, the sulfate bath seems to be in favor. But if we could, by some manipulation, eliminate the two chief disadvantages of the sulfate bath, we would have a more nearly ideal bath.

The work of Thompson[1] of the Bureau of Standards, Washington, D.C., has proved that it is possible to increase the conductivity of sulfate zinc baths by the introduction of conducting salt, such as sodium chloride or ammonium chloride, so that the bath voltage may not be much higher than that of the cyanide bath. Therefore, the only thing which still holds back the sulfate bath is its throwing power. The work being carried on at present is concerned with improving the throwing power of the sulfate bath.

First of all, it was found that throwing power has a definite relation to the pH of the plating bath. A standard sulfate bath was prepared having the following composition:

	Oz. Gal.
Zinc sulfate, dry	20
Ammonium acetate	6.7
Aluminum sulfate	2.7

The above bath was operated at 70° F. and a current density of 15 amp./sq. ft. with varying pH values from 5.3 down to 1, by addition of either ammonia or sulfuric acid. The throwing power was tested by the improvised cavity scale[2] made of a standard ⅜ x 2 inch iron nipple closed at one end by a brass cap. It was found that, starting from a pH of 5.3, throwing power increases with decrease of pH value until a maximum throwing power of 130 on the cavity scale is reached at a pH of 4.2. After that, the throwing power decreases with further decrease of pH.

As the pH value of a sulfate zinc bath changes, the color and texture of the zinc deposit also changes. At higher pH values, the

1. Trans. Am. Electrochem. Soc. *50*, 193 (1926).
2. Pan, L. C., Metal Industry (New York) *28*, 271 (1930); Metal Cleaning and Finishing, *2*, 927 (1930).

deposit was white and dull, with probable inclusions of zinc oxide. At a pH range of 3.0 to 3.8, the deposit was bright and of high quality. At lower pH values, the deposit becomes dark. From these observations, it may be concluded that the most desirable pH value is probably 3.7, at which point the throwing power is still high and the deposit bright.

To control the pH value of a sulfate zinc bath, it is necessary to have some kind of buffer in the bath such as acetic acid, sodium acetate or ammonium acetate and aluminum sulfate. While it is possible to regulate the pH at the proper point, it is still possible to use some other chemicals which, due to their buffer action as well as colloidal qualities, maintain a correct acidity or pH at the cathode surface and a certain cathode polarization, thereby further increasing the throwing power.

A number of these chemicals have been tried and found to be effective in maintaining a high throwing power. These chemicals belong to the class of organic bases which, together with acetic acid, form the correct buffer mixture and maintain the high throwing power. With a mixture of 0.5 oz. of acetic acid and 0.06 oz. of pyridin per gallon, a maximum throwing power was obtained at a pH of 3.7, which throwing power measures almost twice as high as the sulfate bath without the pyridin. It is not quite as high, however, as that obtainable from cyanide zinc bath, but the color of the deposit is far better. Other addition agents tried and found equally effective are anilin, phenol, phenol-sulfonic acid, and beta-naphthol. In operating the sulfate zinc bath at a higher pH than what is customary, a precaution must be taken, that is, to avoid any unnecessarily high alkalinity which might cause a deposit of zinc oxide along with the zinc metal. When this happens, the deposit becomes frosty and porous.

With the throwing power so improved, it is possible to use the sulfate bath for plating intricate articles at a lower cost than has been possible in the past. It is also entirely possible that the sulfate bath may be further improved so that we shall have a zinc deposit from it as bright as chromium and with a throwing power even higher than that of the cyanide bath.

The author wishes to acknowledge the valuable assistance of Mr. Henry Levine for his valuable suggestions and actually carrying out some of the experiments as well as practical tests in a commercial plating plant.

WHAT CONSTITUTES A GOOD BASE FOR A STANDARD ELECTROPLATE

Read at Los Angeles Branch Second Annual Educational Session, March 14, 1931

By E. Lamoureux

Formerly Chicago District Salesmanager for Hanson-Van Winkle-Munning Co.

In relation with the information given on the research plans at the bureau of our Research Associate and reports from the research meeting at Chicago on January 17th, indicate that it is proposed that all activities of research for the next three years are to be spent towards the establishment of a standard of plating on steel and iron which shall be accepted as satisfactory from a corrosion point of view.

In this connection there are a number of elements which it seems to me ought to be taken into consideration and yet are not mentioned in the plans to achieve this most desirable objective.

In my opinion, we should first determine what the standard is to be. Obviously we cannot attempt to establish any standard of plate on steel or iron which can be guaranteed for life. Therefore, any standard of plate on these metals should be based upon its duration expressed in the term of years it is expected to stand the wear and tear of the elements to which it may be exposed.

Some time ago a number of men who have made a study of plating over a period of years went on record in a statement in writing that .001 of an inch of nickel could be considered as satisfactory for all purposes from a corrosive standpoint, and that the only way this condition could be improved upon was by increasing the thickness of the plate. I do not agree with this conclusion, for reasons which will be evident in the following comments:

In the research of plating on steel and iron from the standpoint of increasing the sales value of any product, as well as its durability, it appears that the subject is being considered only from the angle of the application of and thickness of the coating, whereas the condition of the surface to be plated is of paramount importance.

The more recent of the many years I have spent in the plating industry have convinced me that really good polishing on steel and iron has become a lost art, and I am also convinced that until such time as this phase of a really high grade plated finish is re-established we are not going to go very far in the creation of any plating standard.

I will venture the statement that if only a small percentage of the investigations and researches of recent years in plating had been

devoted to similar work in the polishing and buffing room, a great deal of grief in plating would have been eliminated, because the plater has had to bear the brunt of the poorest brand of polishing ever known in the industry. It ought to be obvious to anyone in the industry that it is poor economy, or perhaps like robbing Peter to pay Paul, to try to cover up a poor job of polishing by a large expenditure of costly processes and depositions of costly metals in the plating room, and then take the work into the buffing room and proceed to cut off the most of the coatings by the use of "14" and "16" buffs together with compositions having a necessary cutting effect to bring up a lustre, and yet that is exactly what has been going on all over the country in all production plants, and accounts in a large measure for all the ills for which the plater has been blamed.

It will be of interest here to state what constitutes a really good job of polishing, because I doubt if anyone here is familiar with the nature of such a finish, and I shall use a comparison as an illustration to convey the exact meaning.

All of us are familiar with a highly buffed piece of brass or copper, and also the fact that such a piece of work when nickel plated can be buffed on a relatively small buff to obtain a very high lustre. Therefore, any piece of steel or iron should be polished to such fine finish and high lustre before being plated to enable you to buff the article after plating exactly the same as is the case with brass or copper. That is what constitutes a really good job of polishing.

The claim may be made that such high grade of polishing is prohibitive from a cost standpoint in high production plants. However, I am confident that such an issue is debatable, particularly if proper appliances, tools, or wheels, glue, suitable abrasives, etc., are given serious thought, and proper alignment is engineered to produce a properly polished article.

However, if we grant that the cost to produce a really high grade job of polishing is higher, we should not lose sight of the fact that a really high grade job of polishing before plating would result in a tremendous saving in buffs, buffing composition, power, etc., which in my opinion would more than offset the increased cost of polishing. Another point is the fact that under a set-up of that kind all the metal plated upon any line of product would not be affected by the buffing operation, and therefore, in a great many instances,

an infinitely better job could be turned out with a great deal less amount of plate.

That phase of this subject relating to the proper machinery, alignment of polishing rooms, proper types of wheels for various and sundry kinds and types of work, also suitable sizes of wheels, speeds, glue, and abrasives is too broad and involved to enter into any discussion of it here, but there is no doubt in my mind but what the entire matter is deserving of the serious thought and efforts of the industry. I would also caution against any hurried or hasty counsel or decisions, because, while there are many sources of advice and engineers available in this particular line, at the same time the fact remains that really high grade and actually competent and practical sources of information on this subject are rare and may account for the sad plight of the polishing phase of the industry.

This may sound like an indictment. However, the facts must be faced, and no one can honestly doubt the existence of the situation pointed out, and it is my hope that the matter in question will receive the study it deserves in the industry to produce the better grade of products they are all seeking.

RUST AND RUST PREVENTION

By Gustav Soderberg, Udelyte Process Co.

Read at Chicago Annual Meeting January, 1931

Every electroplater is interested in the question of rust and rust prevention, and many of you stand daily before the problem of how much copper, nickel, chromium zinc, cadmium you have to put on a special lot of work and how to put it on in order to produce a satisfactory coating at a minimum of expense. There are numerous papers written, each one dealing with some special phase of this important subject, and we all eagerly study the literature for more information.

In my own work I am supposed to keep an eye on new developments. Sometimes it is rather bewildering and I find it pretty hard to connect new facts with the old ones and get a satisfactory picture of the problem in question. Then I know that I had better go back to the fundamentals. That is what I propose to do today on the question of rust and rust prevention, because I think that if we know what rust is and why and how it is formed, then we also know a little better how to prevent it from forming.

Rust, well, that is iron oxide containing more or less water, we know that. It is quite interesting to look at an analysis of rust. Here is one made by an old schoolmate of mine over in Sweden on rust from some cannons which had been lying on the bottom of the Atlantic Ocean between 1717 and 1923:

	Fe_2O_3	FeO	*Total Iron Oxides*	*Water*
Outside layer	61.76	8.30	70.06	—
Intermediate layer	53.14	17.77	70.91	14.32
Inside layer	43.82	26.44	70.26	13.79

You will notice that the oxide closest to the iron core contains more iron in a lower state of oxidation than the oxide in the surface layer. This points in the direction that rust, which is ferric oxide, is not the primary product of corrosion but is formed by further oxidation of ferrous oxide.

But we need not go back to such historical things to show that salts of the lowest oxides are formed before the real red rust is developed. If we dip a piece of clean steel sheet in a solution of sodium chloride, for example, and let it hang in the air for a short while, we can see how first a green film is formed on the sheet. This film consists of ferrous hydroxide. A little later this green film turns dark and brown, and if we dry it, the color changes into more of a red, or ordinary rust.

It is a good rule in all research to keep an eye on all possible factors which may have an effect. In the little corrosion experiment which we just described, there are a number of variables, and before we can make a satisfactory picture of what is actually taking place, we will have to study each one of them separately.

First let us exclude the air. If we take the same piece and dip it in the same solution and then hang it in a bottle which contains hydrogen or nitrogen instead of air, we will find that the green coating will be formed but that it does not turn into brown rust as in our previous experiment. We have learned that oxygen is necessary for the formation of rust. If we view this piece at different time intervals, we notice that the rate of corrosion decreases with time and that it pretty soon approaches zero.

Secondly, let us exclude the moisture. This test piece was carefully cleaned and dried with alcohol, and in the top of the bottle we

have arranged for absorption of the moisture from the air by means of calcium chloride. The piece is as bright as when I put it in. Moisture is evidently necessary for atmospheric corrosion.

Now let us exclude the salt from the solution in which we dip our test piece and use ordinary tap water. This time we will let the air have free access to the test piece. We notice that the same phenomenon will repeat itself as in our first experiment, but that the formation of corrosion product takes place at a slower rate. If we use distilled water, the rusting is slowed up still further. Evidently the salt in the solution has quite an effect in accelerating corrosion. If we make a series of experiments using solutions of different concentrations of the same salt, we will find that the rate of rusting increases with the concentration up to a certain point, then decreases. This point of the fastest rust formation coincides with the maximum of the electrical conductivity of the solution if corrections are made for the viscosity which determines the thickness of the solution film, and for the rate of diffusion of oxygen of the solution. Rust formation is evidently in some way or other connected up with the electrical conductivity. I have here some curves which are the results of some work I did at the Royal Technical University of Stockholm, Sweden. On the ordinate is plotted the amount of oxygen absorbed per unit surface area and per hour by test pieces (they were steel pieces of a carbon content = .10) which had been dipped in several different solutions and hung over those solutions in order to preserve the original thickness of the solution film. On the abscissa I have plotted the number of hours since the experiments were started. When we study the general shape of the curves, we notice that the rate of rusting decreases with time. Evidently the rust coating protects the steel from rusting, although not completely. The most concentrated calcium chloride solution in which the rate of corrosion was the greatest does not show much of a drop, however. This is caused by rust particles disengaging themselves from the surface, exhibiting fresh steel areas to the corroding solution. Every curve gives the average of four separate determinations. The greatest variation from the average and the most uneven curves were found for the concentrated calcium chloride solutions, the smallest one for the distilled water.

If we tabulate the electrical conductivity against the rate of corrosion between the 50 and 200 hours we have:

	Conductivity	*Rate of Corrosion*
$CaCl_2$—Soln. 5.5 N.	.20	48
$CaCl_2$—Soln. .5 N.	.04	15
Water, saturated in $Fe(OH)_2$	$.0_41$	5

A certain proportionality is evident. The rate of corrosion, however, is not directly proportional to the conductivity. This cannot be expected, as there are two strongly opposing forces in play in the salt solutions, namely, lower oxygen concentration in the solution film (it is used up so much more rapidly) and greater alkalinity.

The pH of the solution is one of the determining factors in the corrosion of iron. Low pH solutions, i.e., acids attack faster than neutral salts and high pH solutions such as alkalies do not attack at all if they are uniformly distributed over the surface.

If we test a number of different salt solutions, each one in several concentrations, we will find that there are two distinct groups of salts, each group having a particular manner of behavior. To the first group belongs such salts as the chlorides, and sulfates of sodium, potassium, magnesium, calcium and many others. Solutions of these salts attack the steel in all concentrations. The second group can be divided into two: the first one consists of such salts which have an alkaline reaction, and the second one of such salts as chromates, iodates, chlorates and borates which can be named oxygen carriers. At low concentrations, solutions of these salts will accelerate the corrosion, but when the concentration increases, a point is soon reached where they act as inhibitors.

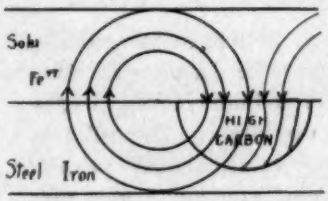
We have now studied the effect of what you would call the outside variables. Let us for a moment turn to the test piece itself. On the surface it has a homogeneous appearance, but if we view it under the microscope we notice that it is quite heterogeneous. There are dark areas and light areas, and if we make an analysis of each one, we will find that they have a different chemical composition. In a low carbon steel the ground mass consists of practically pure iron with imbedded spots which have a higher carbon content. Once I made an examination of a piece of gray cast iron which had been subjected to rusting for a short time. The rust had not yet spread over the entire surface but left certain irregular areas free from rust. These areas I encircled with a sharp point, then polished off the rust, etched the surface and looked at it under the microscope. Then I found that the parts which were not covered with rust

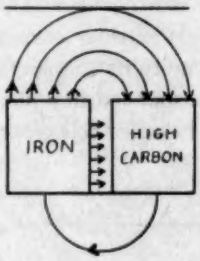
mainly consisted of one of the components of the gray iron, namely, graphite.

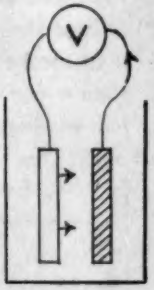
Before we go any further I want to show you a little experiment. Here is a piece of cadmium which I dip in a solution of hydrochloric acid. You don't notice anything but a faint gas evolution. Now if I tie a piece of fine platinum wire around it you will see a rapid evolution of hydrogen—from the platinum wire. If we were to weigh the pieces, we would find that it is the cadmium that goes into solution and not the platinum.

The graphite in the gray iron or the carbon rich pearlite in annealed steel fill the same function during the corrosion of iron as the platinum did in this experiment. When iron goes into solution something else must be deposited out to compensate for the loss. In a copper sulphate solution, it is copper; in an acid or a salt of the alkali metals or the alkaline earth metals, it is hydrogen. But pure iron offers a resistance to hydrogen evolution. It takes a high hydrogen ion concentration, i.e., an acid solution, to precipitate hydrogen on pure iron, which has what we call a high hydrogen overvoltage. The hydrogen overvoltage on both platinum and graphite is nil, and it is low on pearlite.

Here now is our corrosion experiment.

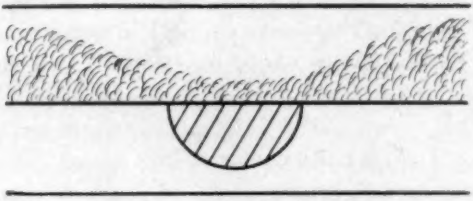






Very similar to the oldest of all cells, Voltas $Zn/H_2SO_4/H_2+Cu$. We can now see how increased salt content of the moisture in the atmosphere increases the rate of corrosion of iron. More current can pass through the solution. We can also see why there was more rust on the lower part of our test pieces. In the thicker water film there is room for more current lines. And the oxygen oxidizes the ferrous hydrate to ferric and the hydrogen to water.

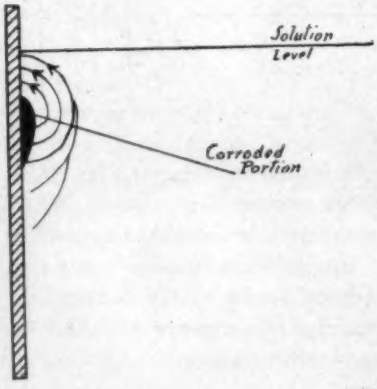
When the rust formation has continued for a while the whole piece is covered with rust, like this—



The resistance to the current has increased considerably. Due to the increase in volume on its formation, the rust always remains porous, the rusting never stops completely.

This change from ferrous hydroxide to ferric explains why the corrosion of iron in the atmosphere proceeds so much faster in comparison with that of aluminum which is a much more active metal chemically. When aluminum corrodes, the aluminum oxide forms much faster than iron oxide to begin with, but it does not undergo any further change but remains on the surface as a layer protecting from further corrosion. The same holds true for other metals more anodic than iron, namely, zinc, chromium and cadmium. Chromium is particularly notable in this respect.

Electric elements causing corrosion may be due to other things than the heterogeneity of the surface. I have here a piece of sheet steel which was suspended in a solution of sodium chloride. I have had to lacquer it in order to preserve its appearance. This solution also contained some phenolphthalein. You will notice that rust has formed on the lower part of the test piece, while the upper part is practically unattacked. You will also notice a red line at the solution line which shows that the solution here turned alkaline. Evidently an electric cell was formed with the upper part as cathode and the lower part as anode. The only difference is that solution



around the upper part is closer to the air and has a higher oxygen content than the solution around the lower part. This is enough for the formation of an electrolytic cell.

The existence of such cells has a great practical importance. It explains the so-called water line corrosion. As the total amount of current is limited by the difference in oxygen concentration, the corrosion is localized to a more or less wide band. The width depends on the conductivity of the solution.

Oxygen cells also explain many a case of pitting. Here is a drop of a salt solution on a perfectly homogeneous metal surface. From what I have said before you can readily understand how corrosion is localized in the center of the drop. Now that drop may dry out, but the next time this surface becomes wet, the presence of rust is sufficient to decrease the diffusion of oxygen to the bottom of the pit and more corrosion sets in.

Let us go back to this test piece of ours for a little while. It was standing in the beaker at an angle of approximately 45 degrees and the side which shows the thickest layers of rust is the one that pointed towards the solution line. On this side you will notice less corrosion around the vertical edges than further in on the test piece. If you look at the back of the test piece you find that the lower edge is free from rust. This is due to the little amount of cold work to which the edges of the test piece were subjected on shearing. It has been conclusively shown that parts under stress by bending, twisting, upsetting, or even quenching in water or oil from a high temperature become anodic towards the less stressed part. In practice this can be offset by annealing.

I also want to mention another source of formation of the electrical elements, although we electroplaters have less to do with this than any of the others already mentioned. I refer to stray currents which are present in the soil and which are one of the most troublesome factors in soil corrosion. Such stray currents originate from electric railways which are having the rail connected to the minus pole of the generator. As you know, the current always takes the electrically shortest path. Now if the rail is badly corroded and the connections between the individual parts are loose, appreciable

resistance to the electric current is set up. If the rail is poorly insulated from the soil and the soil is moist and contains a large amount of salts, part of the current will travel through the soil and there it hooks up with pipe lines. The rail has a cathodic zone where the train is and approximately half way back to the power house. The same thing holds true for the pipe. Close to power houses where the current has a tendency to leave the pipe, the pipes are anodic and severe corrosion sets in. As high current densities have been found in soils at .02 amperes per square inch. This is sufficient to cause corrosion of any metallic object in the path of the current. When below .002 amperes per square inch the current generally does not cause much harm.

The question of rust prevention is a very serious one. We platers often look at rust as a most inconvenient thing that causes rejects, a red figure in our books, and a cause of irritation between us and the boss. It is more than that, however. Rust means great economical losses year after year. It is a source of great concern to our engineers. Here is a man constructing a machine. A certain member is subjected to reversed stresses, say tension and compression in rapid succession for hour after hour, day after day, for a number of years. All right, this piece of material has to stand 40,000 lbs./sq. in. cross section, because the size is limited by mechanical reasons. Then he chooses a material with a fatigue limit of 60,000 lbs./sq. in. and feels safe? Oh, no, he knows that there is something called corrosion, and that there is no material known with a corrosion fatigue limit beyond 20,000 lbs. per sq. in. Now what does he do? Naturally he prescribes that the piece shall be rust proofed, and he specifies a plated coating of a certain thickness which he knows from experiments will give him his 50-60,000 lbs. per sq. in. He gets his specified thickness but—a single blister will ruin that piece of machinery, not to speak of a spot where oxide was not removed and no plate is present at all. If this piece is not rejected, corrosion sets in and soon the member breaks, maybe ruining the whole machine. Such examples can be multiplied. Only think of thin springs in safety devices which, if they break, may cause great damage.

If we look back on our discussion of the causes of corrosion, we will soon discern the different methods which can be used to prevent such corrosion. The basic idea besides alloying, which will change the tendency of the metal to go into solution and which we

cannot discuss here, is to provide a coating which forms a continuous envelope around the object which we want to protect and which prevents moisture and air from reaching the steel. Such a continuous envelope must, of course, be resistant towards chemical attack and the mechanical handling to which the object in question is subjected, or it will soon break down and corrosion will take place as if nothing had been done to prevent it. In our corrosion prevention work we are trying to produce such a continuous envelope.

There are several different coatings employed for this purpose, such as oxide coatings produced by heat, paint, enamel and lacquer coatings; coatings of grease or paraffins, sometimes containing an oxygen carrier such as chromates which ennoble and pacify the steel. In order to make such a grease or oil coating adhere better to the steel, the steel may be parkerized or coslettized, i.e., provided with a coating of iron phosphates. Finally we have the metallic coatings, which may be applied by hot dipping, tumbling with metallic powder under heat, spraying, or electrodeposition. Of these coatings, we are most interested in the ones made by electrodeposition.

The corrosion of continuous coatings takes place along the same principles as laid down for the corrosion of iron and steel. The metal tends to go into solution and hydrogen is deposited out instead. The tendency to dissolve varies from metal to metal approximately according to the so-called table or normal potentials. Here is is for the metals in which we are most interested.

	1 n.	.01 n.	.0001 n.
Aluminum	—1.34	—1.38	—1.41
Zinc	— .76	— .83	— .89
Chromium	— .6		
Iron	— .43	— .49	— .55
Cadmium	— .40	— .46	— .52
Nickel	— .23	— .29	— .35
Tin	— .14	— .20	— .26
Lead	— .12	— .18	— .24
Hydrogen	.00	— .12	— .23
Copper	+ .34	+ .28	+ .22
Silver	+ .80	+ .68	+ .57

The more negative the potential, the easier the metal goes into solution, granted that something else is deposited out instead. In

case of solutions of the alkali metals, this something is hydrogen. We have seen that the presence of oxygen speeds up the solution of iron by oxidizing the hydrogen to water. In case of copper, which is more noble than hydrogen, oxygen in high concentrations is absolutely necessary.

Unfortunately this series cannot be applied directly. There are a number of outside factors that must be considered. The first one is passivity. A fresh aluminum surface oxidizes instantaneously in the air and the film which is formed renders it very much less active than its place in the series would indicate. It actually has a potential around that of iron. Chromium is another example of the change such passivation will cause. Its potential actually drops below that of iron. Other metals have the same tendency to become more cathodic by the formation of protective films.

The climatic conditions and the type of atmosphere plays a very important rôle. In a pure seacoast atmosphere, the moisture which condenses on the surface contains mainly chlorides. Ordinary industrial districts may show a preponderance of carbonic acid, and where coal is burnt which is high in sulphur the air has a high content of sulphur dioxide and sulphuric acid. The air around chemical plants often carries large amounts of acid. In the tropics the air has a high ammonium nitrate content, etc.

Now we know that chromium is rapidly attacked by hydrochloric acid, it reverts from its passive state into active and corrodes rapidly. But it stands up beautifully in an ordinary industrial atmosphere. One metal may stand up better than another in an industrial atmosphere because it forms basic sulphates more easily, while the opposite may be true along the seacoast, because it is more soluble in chloride solutions. Frequent and heavy rains may wash away the corrosion products before they have reached an insoluble state. If the rains come less frequently, the relative corrosion resistance of two coatings may be reversed.

Other factors which change the relative potential of two metals are the solubility and degree of dissociation of the salts formed during corrosion. My time is, however, too short for a discussion of these variables.

Unfortunately the coatings which we produce are very seldom completely continuous. And even if they were, the corrosion and the mechanical handling to which they are subjected will sooner or later disrupt them and expose the base metal.

It is, therefore, most important to see what happens at discontinuities of metallic coatings. I will here draw on some papers by Evans in England who studied the question quite in detail. As soon as we have two different metals in contact with one another and there is moisture present, electrolytic cells are set up. Evans immersed steel together with a number of different metals, namely, zinc, cadmium, aluminum, lead, tin, nickel and copper in distilled water, hard tap water and dilute solutions (M/10) of sodium sulphate and sodium chloride. He then measured the electromotive force set up between the two electrodes and found that zinc and cadmium are normally anodic to steel, that tin and lead are variable at the moment of immersion, but tend to become definitely cathodic towards steel since incipient rusting occurs on the steel, protecting it from oxygen and thus rendering it anodic. Aluminum is generally anodic to steel but becomes cathodic if the steel article is so placed that its surface does not become covered with rust sludge and that the concentration of oxygen is higher on the aluminum than on the steel.

Copper and nickel are usually cathodic to steel, although in the case of nickel the electromotive force may be reversed temporarily by testing a freshly abraded nickel against an aerated steel. These observations are in good agreement with what we learned from the study of the series of normal potentials.

It was also noticed that the sacrificial corrosion of zinc which was subjected to particular study, in some cases ran as high as to make the protection rather valueless over any extended period of time. Such was the case in waters of very high conductivity and when the zinc surface was relatively small in comparison with the steel surface, i.e., when the current density of anodic zinc was very high. Such rapid destruction is naturally more pronounced when the objects are completely immersed in the corrosive medium. When we have to do with atmospheric corrosion the resistance to the current becomes much higher and the sacrifice less. On the other hand, a smaller steel surface will be protected. Bauer, in one of his papers, has found that the current density on the cathode, that is, on the steel, must be at least .01 amperes per square foot in order that complete protection may take place on immersion in a still solution. When oxygen has free access this figure may change somewhat, but it gives an indication of the amounts of current necessary.

In another paper Evans studied the corrosion at actual discon-

tinuities in sprayed coatings of copper, nickel, aluminum and zinc. Different thicknesses were employed in order to get various degrees of porosity. Some thick specimens were bent in order to produce cracks. The test pieces were subjected to four kinds of simulated atmospheric corrosion, namely, short spraying once a day from an atomizer with half normal sodium chloride solution, the same treatment with one-hundredths normal sulfuric acid, exposure to air containing sulfur dioxide and moisture in one case and hydrochloric fumes in another. While the corrosion was greatly accelerated, the tests show that cracks produced by bending are more dangerous than uniformly distributed pores, causing enhanced wastage of the coating metal where it is anodic (for example, zinc) or increased attack on the steel where the covering is cathodic (for example, copper). Aluminum coatings are generally less attacked than zinc but fail to give protection when the solution film is low in salts. Nickel causes much less acceleration than copper. In atmospheric corrosion, rust is formed below the coating and owing to its greater volume soon pushes the coating away from the metal. This effect is particularly noticeable when the adherence of the coating is poor due to presence of grease on the steel surface.

Some of the questions which I have here touched upon may be of only general interest to the plater, who often does not have much to say about the choice of coatings. There are, however, a number of things over which he has command, and before I end I would like to discuss briefly a few practical plating problems.

From what we have seen, the thickness of the coating is of major importance, not only because it takes a longer time to corrode through a homogeneous coating when it is thick, but also because it shows less imperfections, such as pores and pin holes. We should also remember that part of the coating is used in the formation of protective film, and that such films are much more efficient if what remains is comparatively non-porous.

Average thicknesses mean very little from a corrosion resistance standpoint; what counts is the minimum thickness of the coating. There is a great need for simple tests whereby this minimum thickness of different coatings can be determined. The coating on a plated article is generally thinnest in the recesses, and we cannot over-emphasize the importance of using plating solutions with high throwing power. It is not enough to use an alkaline solution instead of an acid solution when protection in holes and recesses is desired.

Attention must be paid also to the exact composition of, for example, your copper cyanide solution. Its throwing power varies greatly with the metal, cyanide and carbonate content.

Very often, however, it is not the fault of the plating solution that coatings are too thin in places. Many times it is the alkaline cleaning which is at fault. One can just as well speak of throwing power in cleaners as in plating baths. In the former we are striving to get as high resistance to metal deposition at the high current density points as possible. The same thing can be applied to alkaline cleaners if we increase the resistance to hydrogen evolution at the high current density points. I only need to point to the electrolytic pickling process, known as the Bullard Dunn process, in which the deposition of lead at the high current density points so increases the hydrogen overvoltage that the current seeks its way into the recesses. I am quite positive when the work is packed into a basket which is immersed in the alkaline cleaning solution, that there is very little current on the pieces in the center. This is the reason why recessed material has a very uneven thickness of coating after barrel plating. When we use a cyanide solution, there is fortunately some cleaning action taking place during plating. Acid solutions, on the other hand, give us bare spots. When quality work is desired the answer to the problem is a bright dip which removes the last traces of grease. The same formula can be used as the one given by Dr. Graham; it works just as well on steel as on brass. A short hydrochloric acid dip will dissolve any stains formed on the steel.

I also want to point to the fact that there are all degrees of adherence between plate and base metal. The greater the stresses are in the coating, the better must be the cleaning. The harder and the thicker the coatings are, the greater are the stresses. I remember several cases when I recommended additions of brightener to our Udylite solutions, that the plater came back and said that the brightener had caused the work to blister. The explanation was simply this, that he had been used to poor cleaning, which, however, did not show up with the extremely ductile and soft coating which he produced prior to the addition of brightener. A little better cleaning and everything was all right again. The same thing may happen when the plater who has been used to producing a single coating of cadmium goes in for plating nickel on top of it. He often has to clean his work better.

Then we have the question of pin holes. I will not go into the

effects of changing composition of plating baths, which for nickel solutions are so well described by a number of authors. I want to draw your attention to the condition of the base metal. Quite regularly I have an inquiry as to how many hours salt spray is equal to a certain thickness, say .0002 in. Udylite. That question can be answered only if you refer to a certain steel. I have seen variations of from 200 to 2000 hours. Cast surfaces generally give lower values than rolled. The protection can be appreciably increased by ball burnishing. Hot rolled steel and steels into which slag has been forced during the rolling operation is not as good as cold rolled material which was well prepared prior to cold rolling. It is very hard to remove all of the slag with ordinary pickling methods. Electrolytic pickling seems distinctly superior. Very fine pores can be plated over and large pores can be plated into. But between the two there are sizes which can be covered only by very thick coatings.

Many breakdowns are caused by poor rinsing prior to plating of porous base metal. If any of the pickling solution is left to stay in the pores, it will start corrosion at this point. Alternate rinsing in hot and cold water will help considerably, as it tends to drive the acid out of the pores. Neutralizing dips are also effective, as the alkaline solutions have a strong tendency to creep into the pores.

Some material is absolutely unfit for plating, and I know that even from an economical standpoint it is cheaper to go over to better materials, even if they command a higher price.

See Convention Notice
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THINGS WE LEARN IN THE LABORATORY

By L. C. Pan*

A paper presented before the Providence-Attleboro Branch of the American Electro-Platers' Society April 3, 1931

Whenever you speak of a platers' class, your mind visualizes at once a place where you may go to learn how to analyze your plating solutions, as if you did not expect anything else that you might also learn in such a class. I grant you that you know more about plating than any chemist that you might get hold of to show you how to run an analysis.

There have been many classes of electroplaters in the various branches of the Society. Many of them have been only short-lived and others are poorly attended. One of the reasons for failures in the past was, as Mr. Dan Wittig has emphatically pointed out, the lack of a definite plan for the students, as well as for the instructor, to follow. In some cases, the platers did not know clearly what they wanted to learn in a class, or what would be of general interest to all so that they could make a plan accordingly.

There is no doubt about a genuine desire on the part of the foreman platers to put an old art upon a scientific basis and to bring the industry up to the minute and at the same time to get rid of a majority of the worries which are so abundant in a foreman plater's daily rounds. But it is not always easy to locate a proper person who understands both chemistry and electroplating and who has the time as well as a deep interest in the educational work.

When we stop to think more carefully, what a foreman plater needs is not merely a method of analyzing his plating solutions. There are things far more important than analysis. After all, he may even leave the analytical work to one of his younger helpers if he himself can make use of the results of an analysis. To speak more specifically, the foreman plater today needs rather a broad perspective of the theory of electroplating as a whole and an understanding of the mechanism, both electrical and electro-chemical, of the various plating processes which he handles every day.

These things can be learned in a production shop, but the average foreman plater is usually so busily engaged in supervising his men and in pushing the production up to the specified quota that he has no time to reflect and no leisure moments to look a little ahead beyond the limits of his shop. It is for these foremen platers that

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some educational work is an urgent need, not so much to teach them how to run an analysis, for they have already too much work on hand to take care of, but to teach them the more fundamental things so that they will truly master the science of electroplating.

Such is the purpose of the course in Practical Electroplating at the College of the City of New York, and with this purpose we plan our course and improve it year after year.

Some of the things we take up in the Practical Electroplating Class at C.C.N.Y. are as follows:

1. Theory of electric dissociation, which is the foundation of the whole electroplating science.
2. Faraday's law, which is the basis of all quantitative computation in electroplating.
3. Anode and cathode efficiencies, which affect the plating time and the thickness of deposit.
4. Electrode potentials and polarization, which determine adherence and smoothness of deposit.
5. Conductivity and resistance of plating solutions, which affect the throwing power and bath voltage.
6. Studies in the effect of temperature, current densities and other operating conditions.
7. Hydrogen-ion concentration or pH.
8. Throwing power.
9. Corrosion tests.

In the laboratory we go over these topics in an experimental way. Information that comes through your ears may be forgotten, but information you obtain by performing an experiment yourself will be remembered the rest of your life—"knowing by doing."

Of course we have analysis, too, but emphasis is not on the details of procedure but rather on the principles and ideas behind each procedure.

For those of you who have not a chemical training or have not been sufficiently informed on electrochemistry, it is well worth while to keep a list of topics such as I have mentioned, and make a point of understanding them thoroughly, and when you go to a class or to school do not expect your instructors to tell you everything you want to know, because in electroplating there are many things the instructors themselves do not know. But remember always that nature is your best teacher. What you can learn from an instructor is insignificant indeed compared to what you may learn from nature.

Go to the laboratory and work all by yourself, and the atoms, the molecules, the ions and electrons will all come to teach you.

THE TITRATION OF FREE CYANIDE IN COPPER BATHS

By M. R. Thompson

Read at Washington Convention, 1930

I. Introduction

In the course of analytical studies of cyanides and their solutions, information was obtained on the titration of free cyanide in copper baths, which should be of interest to platers and plating chemists. The conclusions only have been previously mentioned in the Pittsburgh Meeting volume of the Transactions of the American Electro-Chemical Society[1]. In the present report details and reasons will be discussed.

No originality is claimed for the procedure to be described. The titration of alkali cyanide by means of silver nitrate was published in 1851, and the addition of potassium iodide to the titration as an indicator in 1895. What appears to be by analytical procedure the true double cyanide present in copper baths was detected many years ago. Recently, in 1927, Bonner and Kaura[2] at the University of Utah gave a good interpretation of the situation and a general method, but did not describe their procedure in detail. Still earlier, in 1914, Burt-Gerrans and Morrison[3] at the University of Toronto, in cooperation with the Toronto Branch of the American Electro-Platers' Society, published an excellent study of the method. They included details of the procedure and discussed the effect of impurities present in the bath, but did not state the formula of the double cyanide compound. The procedure to be described by the present writer will not be found essentially different from theirs, but will advocate the use of somewhat more potassium iodide indicator and will emphasize and discuss the importance of this salt. As to additional work on this subject, valuable information has been given by Clennell[4], whose classical textbook is familiar to most of you. Finally, it is known that some plant chemists have used a similar procedure for many years.

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1. M. R. Thompson, Discussion, Trans. Am. Electrochem. Soc. 56, p. 405; 1929.
2. W. D. Bonner & B. D. Kaura, Chem. Met. Eng. 34, p. 84; 1927.
3. J. T. Burt-Gerrans and G. O. Morrison, Quarterly Journal American Electro-Platers' Society, 1914; University of Toronto Studies No. 101, 1914.
4. J. E. Clennell, "The Chemistry of Cyanide Solutions," 2nd edition, pages 10, 38 (1910). McGraw-Hill Book Co.

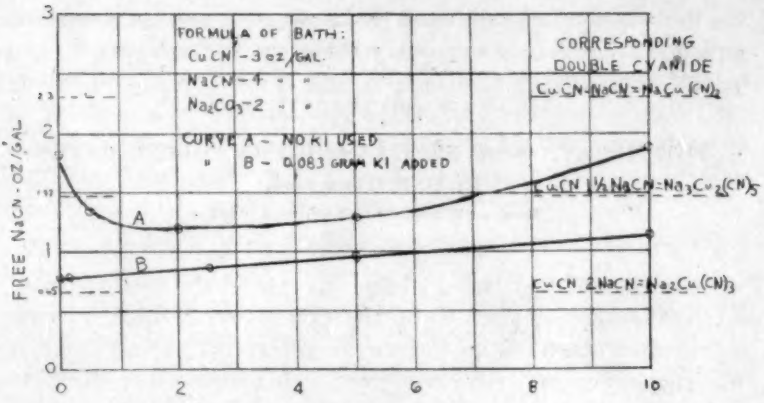

FIGURE 1

Titration of Free Cyanide Content of Copper Bath
Concentrated NH_4OH Added to Titration by N/10 $AgNO_3$—ML
Volume of Titration—100 ML

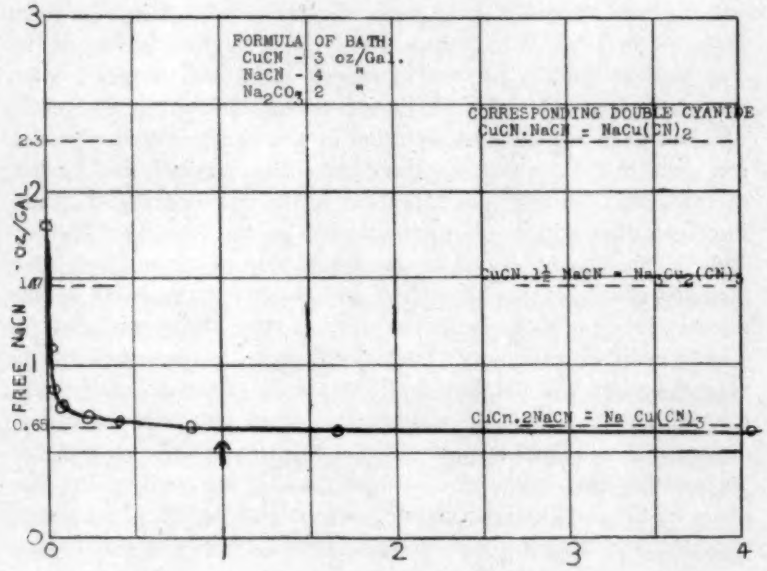

FIGURE 2

Titration of Free Cyanide Content of Copper Bath
KI Added to Titration by N/10 $AgNO_3$—Gram
Volume of Titration—100 ML

The present report will merely attempt to bring all of this information up to date and to lay emphasis upon a few of the important points involved in the procedure and the calculations. A graphical presentation will be found helpful in bringing out some rather striking relationships.

II. Experimental Work and Results

In the recent work done at the Bureau of Standards, high grade commercial chemicals, such as are used by the platers, were employed to prepare a synthetic bath sample having the following typical composition:

Table 1

Cyanide Copper Bath

	N	*g/L*	*Oz./Gal.*
Copper cyanide (CuCN)	0.25	22.4	3.0
Sodium cyanide (NaCN)	0.60	29.4	3.9
Sodium carbonate (Na_2CO_3)	0.30	15.9	2.1

The free cyanide content of this sample was titrated with N/10 silver nitrate at room temperature, under various conditions. The final volume of the titration was kept at about 100 ml, which is a satisfactory dilution for observing the end point. The accuracy was probably about 2 per cent, corresponding to plant control work.

In Figure 1, Curve A illustrates the effect upon the result of varying amount of ammonia added to the titration, in the absence of iodide. It will be seen that the free cyanide determination cannot be readily stopped at a point corresponding to any definite double cyanide compound, that is, the result is difficult to interpret. At first, as ammonia is added, the apparent free cyanide decreases. This effect may be due to the formation of ammonio-copper complexes, which take up cyanide. Later, in the presence of more silver, the free cyanide reaches a minimum and then increases gradually as the ammonia is increased. The latter effect is the usual solvent action of ammonia on silver cyanide, causing a delayed end point and a high value. It will be seen that the use of ammonia alone leads to no desirable result.

In Figure 1, Curve B illustrates the effect of varying the ammonia when a small constant amount of potassium iodide indicator is always added. The latter corresponds to the common recommendation of 10 cc of N/20 KI (about 0.08 gKI). The apparent free cyanide is always lower than for Curve A and is proportional

to the amount of ammonia added throughout. The iodide seems to have broken up ammonio-copper complexes at the start. Just as for the latter part of Curve A, the free cyanide increases with increase in ammonia, which may be attributed to a similar reason, in this case the slight solvent action of ammonia on silver iodide, resulting in a delay of the end point as before. As with curve A, except approximately at the beginning, the determination does not stop at a satisfactory correspondence with any definite double cyanide.

The conclusions obtained from Figure 1 are, then:

(a) Ammonia without potassium iodide does not yield a satisfactory procedure.

(b) A procedure without either ammonia or iodide (first point of curve A) is not satisfactory.

(c) The presence of a little iodide and a little or no ammonia (first point of curve B) is promising for determining free cyanide in excess of the double compound $Na_2Cu(CN)_3$.

In Figure 2, the latter point is followed up by varying the iodide indicator from small up to rather large amounts and with results of significance. The curve shows that the free cyanide determination is not stopped definitely and reproducibly until a favorable flattening occurs, in the vicinity of 1 g KI, after which there is very little change with larger amounts.

III. Action of Potassium Iodide

The reason for the marked effect of KI and for the shape of the curve probably lies in the fact that, as the KI is increased there is more tendency for AgI to precipitate, rather than for $AgNO_3$ to partially attack some of the combined cyanide and thus lead to an indefinite result. When the KI is low in amount or absent, some such reaction as the following may occur to a certain extent;

$$AgNO_3\ 2Na_2Cu(CN)_3 = NaAg(CN)_2\ 2NaCu(CN)_2\ NaNO_3$$

In this case, one of the higher or more complex double compounds is changed to a lower. If, however, there is sufficient KI present, the following desired reaction (a) ends exactly as reaction (b) begins and the higher double compound is not affected:

(a) $AgNO_3 + 2NaCN + Na_2Cu(CN)_3 = NaAg(CN)_2 + Na_2Cu(CN)_3$
(b) $AgNO_3 + KI = AgI$ (end point) $+ KNO_3$

The 1 g. KI mentioned above is somewhat more than is usually recommended or used. It causes the result, however, to correspond exactly with the combined cyanide present as the double compound

CuCN, 2NaCN, or $Na_2Cu(CN)_3$. The existence in solution of this compound $Na_2Cu(CN)_3$ has been recently demonstrated by Glasstone[5] not from chemical, but from polarization measurements, which are closely related to the actual conditions of electrodeposition. This makes a corresponding analytical procedure all the more significant and desirable.

In continuing this work it was noted that the addition of a few drops only of ammonia made the end point somewhat sharper, without materially changing the result when enough iodide was present. The use of a small amount of ammonia is, therefore, an optional matter. The arrow on the curve of Figure 2 represents a satisfactory procedure, which is recommended for plant control work.

IV. Procedure Recommended

Determination of Free Cyanide in Copper Baths:

Reagents:

0.1000 *N* $AgNO_3$ (16.99 g/l)
0.25 *N* KI (42g/l)

Take a bath sample of 20 ml, or as may be necessary. Add 25 ml of KI solution (about 1 g KI). Add not over 1 ml concentrated ammonia, if desired (not always necessary). Add enough water to finish the titration in a volume of about 100 ml. Titrate the free cyanide with the standard N/10 silver nitrate solution, stirring well, until a slight but definite turbidity, or rather opalescence, appears and persists.

1 ml $AgNO_3$ = 0.00980 g NaCN = 0.0654 oz./gal. Free NaCN, for a 20 ml sample

A 20 ml sample of a new bath like that listed in Table 1 requires about 10 ml of $AgNO_3$ solution.

The above procedure determines all of the free NaCN in excess of that combined with copper as $Na_2Cu(CN)_3$. From a determination of the copper content of the sample, by the thiosulphate or electrolytic method, the amount of combined or fixed sodium cyanide is, therefore, readily calculated as follows:

1 oz./gal. Cu x 1.54 = oz./gal. Combined NaCN
The sum of the free and combined gives the total NaCN

The complete results for the above bath are given in Table 2:

5. S. Glasstone, Jour. Chem. Soc., London, p. 690; 1929.

TABLE 2

Cyanide Copper Bath

Formula	*N*	*g/l*	*Oz./Gal.*
Copper cyanide (CuCN)	0.25	22.4	3.0
Sodium cyanide (NaCN)	0.60	29.4	3.9
Sodium carbonate (Na_2CO_3)	0.30	15.9	2.1
Analysis			
Free cyanide (NaCN)	0.10	4.9	0.65
Combined cyanide (NaCN) in $Na_2Cu(CN)_3$	0.50	24.5	3.25
Total cyanide (NaCN)	0.60	29.4	3.9
Copper (Cu)	0.25	15.9	2.1

In practice, particularly with an old or cold bath, more free cyanide than the above may be necessary. This formula is merely used as an illustration and should be so considered.

V. Effect of Impurities

Cyanide copper plating baths accumulate impurities in time. Two of the commonest are carbonate from the decomposition of cyanide, and ferrocyanide from the iron of tanks and in rinse waters. A relatively large amount of each of these salts was tried, and found to have a negligible effect upon the accuracy of the free cyanide titration as outlined. These results would be expected, from the well-known action of potassium iodide indicator. From all the information obtainable in the literature, it seems unlikely that other impurities would be present in large enough amount to seriously affect the result.

VI. Conclusion

In conclusion, the procedure which has been described was used for some months under operating conditions at the Washington Navy Yard by W. P. Barrows, with entirely satisfactory results, for control purposes.

Chairman Gehling: Is there any discussion?

Mr. Harvey Gausing: Is there any appreciable difference in the solution if sodium thiosulphate is in there?

Mr. Thompson: Yes, sodium thiosulphate is well known to be a substance which does not affect this titration, but it takes quite a lot of it to make any pronounced effect. I was only working to an accuracy desired of about 2%, which is ample for control purposes, and it would take a large amount of sodium thiosulphate to bring you outside of that figure, and I don't think more than a gram or two or a few grams per liter are ever used.

MR. GAUSING: Well, you will find the average plater, he uses not much at any one time, but his solution after it is two or three years old has quite a bit of sodium thiosulphate in there. Maybe he adds a little today and a little next week, but in a year's time he has an ounce or two ounces in his solution, if it isn't dragged out, and it might make a difference in the titration.

MR. THOMPSON: Well, that particular man with a particular solution will always get comparable results because he will have fixed values there. His free cyanide today will be about as good for his purpose as it will be next week.

MR. GAUSING: Does sodium bisulphide make any difference?

MR. THOMPSON: I believe it will make a slight difference. All those things were tried in generous amounts by Professor Gerrans. His article was published in one of the early Quarterly Review numbers before the MONTHLY REVIEW started, and I don't know if any of you have the file that far back, but he shows it takes large amounts of thiosulphate and bisulphide to upset this very much. We only need an accuracy of 2% or 3%.

DR. WM. BLUM: Is it safe to say thiosulphate doesn't stay in there, but is decomposed and that is why he has to add a little more?

MR. THOMPSON: I think that is possible. It is not a very stable compound.

CONVENTION NEWS

The nineteenth Annual Convention of the American Electro-Platers' Society will be held at Hotel Seneca, Rochester, N. Y., June 29-30, July 1-2, 1931.

There are two things which presage a successful convention, namely, a good program and a large attendance. The program depends on the convention committees, but the attendance depends on the Society at large. The Rochester Branch is working hard to put this convention over, and *"We Are Going to Put It Over."*

We assure you of a most satisfactory and profitable program. Whether you benefit by our efforts depends entirely upon yourself, so it behooves you to start making plans to attend, otherwise our efforts will be for naught.

You also have the opportunity of meeting personally the men who are working out problems in a scientific way, and able to talk over the difficulties you may be having in some part of your daily routine. This is your convention and for your benefit, so do you share by attending. "We welcome you" to this educational gathering and a good time.

Anyone wishing to present a paper please correspond with Mr. R. Lopez, 72 Wilbur St., Rochester, N. Y., and for exhibits with Mr. H. Puffer, 126 Catalpa Road, Rochester, N. Y.

A. E. S. PAGE

Dr. Wm. Blum and Dr. A. K. Graham attended the meeting of the American Society of Testing Materials in Pittsburgh, March 16 and 17. The A5 Committee on Corrosion held a meeting which both attended representing our Society.

* * *

Dr. Harry Lukens has resigned as chairman of the Committee on Standardization. This is to be regretted, as Dr. Lukens is well qualified to act on this important committee.

* * *

George B. Hogaboom will address the Boston Branch on May 17. His subject will be "Nickel Plating."

* * *

The Electro-Chemical Society held their spring meeting in Birmingham, Alabama, April 26-28, at which 10 papers on electrodeposition were read—one on the electrodeposition of Tungsten. Dr. A. K. Graham was in charge of the electrodeposition sessions.

Newark Branch took no chances. There were three doctors on the program at their annual meeting and banquet.

* * *

Jacob Hay, chairman of the Research Committee, has some interesting articles being printed in the REVIEW which every member should read—then act.

* * *

At the annual meeting and banquet of the Bridgeport Branch the Supreme Society was well represented. President Gehling, First Vice-President O'Connor, Past President Horace Smith and the Editor attended. George B. Hogaboom and Oliver Sizelove presented papers. Ray O'Connor had charge of the educational session. Ray makes a good presiding officer.

* * *

Dr. C. L. Mantell, instructor of electroplating at Pratt Institute, Brooklyn, N. Y., gave a talk to the Waterbury Branch recently.

PRESIDENT'S LETTER

Now that the time is here for the nomination and election of Branch Officers and Delegates to the Rochester Convention, it should be the duty of every member to attend their branch meeting and take part in these important elections.

Don't stay away from these meetings because you don't want to be elected an officer, or that you don't want to be appointed on a committee. Just remember that there are times when you are pleased to inform some people that you are a member of the Society, and that it is a grand Society, then stop to think what it takes to make it a grand Society, and ask yourself what you have done to make our Society just what you think it should be.

Don't let the other fellow run the meeting for you. Get busy, do your share, take an active part the same as he does, even though your views are not the same as his, believe in him and get him to believe in you, and probably after you both have exchanged views you both may get a better view than the one either of you had before.

Also a word as to the elections of the Officers of the Supreme Society. I believe that all the branches should take a deeper interest in this, and express their choice and have their delegates make their nominations. Each branch should be interested to the extent of expressing their own choice without waiting to see who the other branch or other delegate is putting forth.

In making arrangements for your vacation this summer, remember that our convention takes place in Rochester on June 29-30, July 1 and 2, and what better time and use can you make of your vacation than in combining business and pleasure together and bring your family to the convention in Rochester, N. Y., and which is far enough north to avoid the extreme heat, and the Rochester members as hosts can be depended upon to see that everyone will enjoy their visit there.

GEO. GEHLING, *President.*

To the Membership of the A. E. S.

IN THE April issue of our REVIEW, I addressed you on the subject of our Research needs and informed you as to what was anticipated by the Research Committee and the Research Associate at the Bureau of Standards.

This issue of the REVIEW carries with it the summary of the Research meeting held in Chicago in January of 1931. This should suffice to inform you as to the importance of our Research program at all times and more especially now.

We are fortunate in having two such excellent men as Dr. Blum of the Government and Mr. Strausser, our Research associate, to aid us in our Research work. And with such excellent facilities as the Bureau of Standards at Washington affords, we, as members, should find out whether our employers have contributed to the Research fund, and, if not, why not. It may be quite possible your employer has never been approached on the subject and so has not been informed of the benefits which would result to him. If you cannot sell him or do not have the courage to approach him, you owe it to the Society to send in the name of the man in your company to be approached, and I, through our sub-committees, will send the proper literature and get him interested.

The time is short before our next Annual Meeting. Unfortunately the chaotic condition of our country in the past year has caused us to proceed slowly. The demand for a better set of standards for electroplating is greater now than it was a year ago, and if we expect to continue to advance with the progress of time and come out of this economic struggle equipped to keep astride of all industry, we must get busy at Research. I beseech you to send information to me at once in order that we may obtain sufficient funds to do these things, and the members of the A. E. S. and the industry will profit thereby.

Kindly send all communications to Jacob Hay, Chairman of Research Committee, 6920 N. Ottawa Ave., Edison Park, Chicago, Illinois.

BRANCH NEWS

DETROIT BRANCH

Detroit Branch held its regular monthly meeting Friday evening, April 3, at Hotel Statler—President Jos. H. Hansjosten presiding. After the regular order of business, the meeting was turned over to the librarian, Mr. Bernard Lewis, who conducted the question and answer box.

Question—Can nickel be successfully plated on die cast metal which has been cadmium plated to prevent the pitting and corrosion of this metal by the atmosphere?

Answer—Experience has shown that any metal deposited on die cast metal (zinc) from an alkaline solution is very liable to blister, especially if subjected to subsequent cleaning and plating operations. Aside from the difficulty of plating cadmium on zinc castings, it is brought out that the resistance of the casting to corrosion is in proportion to the absence of impurities in the casting itself. It is stated that the American Society for Testing Materials is preparing standard specifications for die cast alloys with reference to corrosion resistance in the so-called "steam test."

Question—What kind of anodes are the most efficient for chrome solution?

Answer—Hard lead. See paper by Dr. O. P. Watts in A. E. S. REVIEW.

Question—What is the best composition for coloring nickel before chrome plating?

Answer—The prime requisite of any nickel composition is that it must adhere to the color buff and have sufficient abrasive action to quickly produce a deep luster free from noticeable scratches, with a minimum pressure to avoid overheating and oxidation of the nickel surface. If the nickel is to be cleaned in alkali before chroming, the composition should, of course, be free from unsaponifiable fats and greases. If the work is not cleaned prior to chroming, the composition should be free from greases having a melting point higher than the operating temperature of the chrome bath.

Question—Is anyone running a low pH nickel solution? If so, please give results.

Answer—Refer to A. E. S. REVIEW for March, 1931.

Question—What is a good tin solution?

Answer—Sodium stannate, 12 oz. per gal.; sodium acetate, 2 oz. per gal.; caustic soda, 1 oz. per gal. Operate at 10 to 25 amps. per square foot and 135 to 150° F.

Question—Has anyone present had any experience tin plating and afterwards nickel plating on top of the tin plate?

Answer—Present practice by some producers of automobile radiator screens is to first tin plate by the hot dip process, then apply bright deposits of nickel, copper, nickel and chrome.

Question—To what extent have chemical or plated finishes returned to favor as against the sprayed and enameled finishes on builders' hardware and chandelier work?

Answer—Polychrome and highly colored effects on these products will no doubt be supplanted in public favor by the more subdued and naturalistic effects obtained by plating and chemical coloring, as all such fashions are subject to rotations or "cycles."

Question—Will a deposit of chromium directly on brass hold up for any length of time?

Answer—Brasses having a comparatively low zinc content and plated with a heavy deposit of chrome (15 to 20 min.) are said to be fairly satisfactory. Thin deposits on any brass are very short-lived. Readers of the REVIEW are asked to comment on this subject.

Question—Is continuous filtration successful for a large nickel solution?

Answer—It is stated that a 6000 gal solution has been in operation for 18 months with continuous filtration without cleaning the tank.

Question—Is there any benefit derived if a nickel solution is neutralized with nickel carbonate before filtering?

Answer—Zinc and iron are removed if sufficient time is allowed before filtering.

Question—Has the pH of a nickel solution any influence on pitting?

Answer—It is known that nickel may be deposited free from pits within a large range of pH, depending entirely on the control of other factors, largely by the use of hydrogen peroxide.

Question—What is a good acid zinc solution?

Answer—Zinc sulphate, 8 to 12 oz. per gallon. Aluminum sulphate is added in small quantities to produce the desired whiteness of color.

CHAS. M. PHILLIPS, *Secretary and Treasurer.*

ROCHESTER BRANCH

Rochester Branch held its monthly meeting at the Seneca Hotel, Friday evening, April 17, with a very good attendance. President Reama was in the chair.

Our members are sure interested in the coming convention in our city and are doing all in their power to make it a success. The various committees are holding weekly meetings and we know that you will miss a very good convention if you are not at Rochester this year. The committee on papers are very anxious to have all those who intend to read papers send in their titles at once so we can have them for the convention program. We wish the branch secretaries would help us and send their titles to Mr. Lopez at once. This would help us very much. Trusting all who intend to read papers will cooperate.

CHAS. GRIFFIN, *Secretary.*

WATERBURY BRANCH

The April meeting of Waterbury Branch, A. E. S., was held on Friday evening, April 10, and was presided over by President Wm. J. Gray. Routine

business was transacted, after which the meeting was turned over to Mr. Wm. B. Price, chief chemist and metallurgist of the Scovill Mfg. Co. The speaker took for his subject, "The Technical Method of Control." Accompanied by lantern slides, the address and pictures made an interesting evening for all present. After extending the thanks of the meeting to the speaker for the entertainment presented, the chair announced that the reports of all officers and committees would be presented at the May meeting, and the annual election of officers would take place. A request was also made that the Branch members turn out 100% at the May meeting, as arrangements were being made by the Entertainment Committee for a special treat on that evening.

Meeting closed with a social session, refreshments being served.

W. F. GUILFOILE, *Secretary.*

LOS ANGELES BRANCH

The second annual banquet and educational session was held March 14 in the Chamber of Commerce Building.

The papers read at the educational session in the afternoon proved interesting and were as follows:

"Message from the Supreme President," by G. Gehling. Courtesy E. Lamoureux.

"Summary of Plating Research Bureau"—Dr. Wm. Blum. Courtesy E. Lamoureux.

"What Constitutes a Good Base for a Standard Electroplate." Courtesy E. Lamoureux.

"Electro-Deposition of Rubber." Courtesy Earl Coffin.

"History of Chromium Plating" (Continued). Courtesy E. Lamoureux.

"The Necessity of Chemical Control of Plating Solutions." Courtesy A. A. Bissiri, M. A.

QUESTION BOX FORUM

Courtesy R. U. Gripp, Branch Librarian

Question—Has the cause of pitting of nickel deposit ever been settled?

Answer—No.

Question—What is the best possible ratio of chromic acid to sulfuric acid for job plating?

Answer—100 to 1.

Question—On emptying our silver tank we found about one inch of crystallized substance; it looks like ice. What is it? Is it advisable to put it back in the solution or recover the silver from it and throw it away?

Answer—The substance is sodium carbonate, and see our chemistry instructor to show you how to recover the silver.

Question—Why do 92% nickel anodes dissolve better than 99%?

Answer—99% anodes will dissolve if you use sufficient quantity of chloride.

Question—How can bronze or red brass be oxidized to a statutory bronze finish without staining or leaving finger marks?

Answer—Hot, weak lives of sulfur dip and very weak sulfuric acid dip. Use alternately, then scratch with brush to uniform color.

Question—Is there a method of spraying lead for lining tanks?

Answer—Yes.

Question—What is Plat-Nig used for?

Answer—Oxidizing silver.

Question—What is the best method to silver plate reflectors?

Answer—Clean, use mercury dip, then plate in regular silver solution containing 4 pwt. of cadmium oxide to each gallon.

Mr. Benjamin Foss gave a thorough explanation and reasons for various operations. Ben will be asked to write a paper on this subject, as he sure knows his onions.

Some beautiful examples of real plating as a finishing were exhibited by the following:

S. & M. Lamp Co., Coast Enameling & Plating Co., Dazey Mfg. Co., Electroplating Shop, Harvey Machine Co., L. A. Rubber Stamp Co., Merigold Plating Co., National Brass Works Inc., Price Pfister Brass Mfg. Co., Repcal Brass Co., Russill Plating Works, U. S. Bumper Co., Western Enameling Works, Laguna Beach Novelty Co., Angelus Plating Works.

These exhibits were so good that several times while dancing in the evening the ladies would stop to admire them.

Prizes were donated by the following firms:

L. A. Chemical Co., Maas Waldstein Co., National Brass Foundry, Dazey Mfg. Co., L. A. Rubber Stamp Co., Western Enameling Co., Pacific Gas Radiator Co., U. S. Bumper Co., S. & M. Lamp Co., Price Pfister Co., Universal Chemical Co., American Die Casting Co., Chas. F. L'Hommedieu & Co., Harvey Machine Co., Russill Pltg. Wks., Hussander & Martin, National Chemical Co., L. H. Butcher & Co., C. Koucour, Oakite Products Co., Braun Chemical Corp., Edison Electric Co., Turco Products Co., Public Service Brass, Coast Heater Co., Mefford Chemical Co.

These donations were drawn for or won by the bridge players during the course of the evening.

After a splendid turkey dinner had been disposed of, dancing, singing and card games were indulged in, and at the close everyone declared they had had a wonderful time.

A good deal of credit is due the committee for the successful affair.

M. D. Rynkofs, *Secretary-Treasurer.*

PHILADELPHIA BRANCH

The regular monthly meeting of Philadelphia Branch, A. E. S., was held at the Harrison Laboratory, University of Pennsylvania, on March 3, 1931—President Lunbeck presiding.

Our plating class at the Mastbaum School has closed the winter term and held their annual class dinner at Adams on Monday, April 30. The class covered the analysis of the chrome solution, and the members have a thorough knowledge of the chromium solution. Officers were nominated and elections will take place at our May meeting.

Under the rule of Good and Welfare, the librarian, Mr. George Long, introduced Mr. Harry L. Miller of the Quaker Chemical Co., to give a talk on "Specialty Oils," the oils which are used to fabricate the metal parts before they are sent to the finishing department.

MR. HARRY L. MILLER: The specialty oil industry is somewhat apart from your interests in metal cleaning, and electroplating, and so on. I don't know anything about electroplating, but I do know that very often I hear things about it that are of interest to me in my business, and I think perhaps the information that you will get out of what I have to say might be of some benefit to you in the electroplating business, although you might have to carry it back in your mind for some later day when something I might say here tonight might apply.

Specialty oils are different from the regular run of oil products. As you know, the average oils are animal, vegetable, marine, or mineral oils, and they are either pressed from seed, as in the case of vegetable oils, or they are pressed from fats, in the case of animal oils, and in the case of mineral oils, they are distillates from crude. The specialty oil industry is altogether different.

The first specialty oil product was made by a Scotchman by the name of James H. Young. He set out to make a product for illuminating purposes that would be better than Sperm Oil, which was the standard staple used for lighting purposes during that time.

In 1847 he succeeded in distilling a product from coal and shale, which WAS better and cheaper than Sperm Oil. He called it Coal Oil, but this product was no more than the regular kerosene that we know of today and which is made in very large quantities. And so, when we refer to a specialty oil product, we have reference to a product made for a specific purpose that will do a particular job better than any staple or straight run product.

Originally oil specialties were regarded as substitutes, but in recent years the metal industry has advanced so fast and has undergone so many changes that the so-called staples are no longer efficient in themselves to meet the exacting demands of modern industry.

A technician working in this field must have a thorough knowledge of all the physical, chemical and practical characteristics of the oleaginous products which consist of the animal, vegetable and mineral as well as the marine oils, fats, and waxes. He should know their reactions with the various metals—the changes effected

by heat and cold, by salt air, acids, alkalies, steam, water, lacquers, bacteria and the various composition products with which the oil and grease will come in contact in practical use. In addition to this, he must have a general working knowledge of the various processes in which the products are used and know about the subsequent operations through which the metal will travel in order that only those products are used that will offer no resistance to scouring, finishing, etc.

Tonight we will discuss two classes of the most important specialty products used in the metal industry, namely, cutting oils, compounds and drawing lubricants—then if we have time we can discuss heat treating oils, rust preventives, colloidal oils and special greases.

About twenty-seven years ago the metal industry was called upon seriously to produce a new vehicle of transportation to replace the old horse and buggy. You know the progress of the automobiles produced in that day and can make your own comparison with the present-day models. Picture the radical changes that have taken place since that time in metals, alloys, processes, finishes, etc. One of the important requirements of the advancing industry was for mediums that would give perfect cutting jobs and permit the speeding up of the machines giving a better finish, prolong the life of the tools, dies, etc., at reduced costs.

At about the time the automobile came into use, the staple cutting medium in use at that time was lard oil. This product had its advantages, but it also had definite limitations and some disadvantages. First, it was higher in price than necessary, it also had a tendency to solidify in the machine on standing over a cold night, it had an unpleasant odor and tended to become rancid very easily. Furthermore, the body or viscosity of lard oil was not suited for the various higher speeds that came into general use. Therefore, it was necessary to either improve the lard oil to make it suit these conditions or make another product totally different that was better adapted for the particular jobs. The first step was to cut or adulterate the lard oil with mineral oil. The only advantage to this step was that it reduced the cost and also tended to lower the cold test of the finished product. These diluted products were originally called mineral lard oils, and they really would work as well as the staple product itself providing the mineral content is not too high. However, the percentage of mineral oil continued to climb until now a

so-called mineral lard oil might contain as much as 90% mineral and only 10% lard.

These changes did not begin to cope with the ever-increasing demand for specific cutting oils, and the chemists of the various specialty oil houses began studying the types of metal being cut, the volume and the flow of the cutting medium, the life of the dies, angle of the cut, speed of the machine and kind of finish produced. These were scrutinized from every practical and theoretical angle. After repeated experiments various type cutting oils began to appear that contained no lard oil, nor did they resemble the old staple product in any respect.

Considerable study was given to the heat convection of the various oils or the ability of certain types to absorb and radiate heat faster than others. It was found that any cutting oil with a high specific heat and rapid convection current of low viscosity was ideally suited for the fast machining operations. A product of this type could out-perform lard oil from every conceivable angle. Furthermore, it is cheaper, contains antiseptics that prevent bacterial growth which so often resulted in infection to the workmen, is thin enough in body to run off the work quickly and as a result the consumption is materially reduced, the improved products do not solidify under slight changes in temperature and as a general rule are pleasant smelling.

Some of the chemicals introduced in the new type cutting oil consist of sulphur, naphthalene and colloidal clays. The sulphur is far superior to any of the other chemicals, that it is really the only one worthy of discussion. By taking an ordinary paraffine oil and chemically combining sulphur with it you can get a decided improvement in finish, die life and precision of cut. The reason for the chemical properties imparted to a cutting oil by sulphur has been a subject of widespread discussion, but the general accepted and most logical reason is that due to the high specific heat of the sulphur it gives to the paraffine vehicle those properties which have been found indispensable in any first-class cutting oil, namely, that it has the characteristic of absorbing and radiating heat quickly. The same principle applies through the addition of kerosene or turpentine, which products are often added to smoking cutting oils and after the addition of these products the smoking usually stops. Here again it is the same principle of heat absorption and radiation.

Until recent years it was generally accepted that a good cutting

oil must possess unusual properties of oiliness or lubricity, but this theory is no longer considered seriously. Since the introduction of sulphur and the widespread knowledge of its effectiveness in cutting oils, there have appeared on the market various cutting oil concentrates. These products consist principally of fused sulphur in combination with either a selected straight mineral oil or a straight animal oil, or in some cases a combination of all. By taking one part of these cutting concentrates and mixing with paraffine vehicle like 28 paraffine oil, fuel oil, etc., very efficient cutting oils can be made to suit any particular operation. On tough alloy steels requiring an extra good cutting oil, the amount of the vehicle is reduced, and on the lighter cutting jobs the amount can be increased, therefore enabling the consumer to have the option of making either a good cutting oil for the better jobs and a cheaper cutting oil for the lighter operations.

The fact that a good cutting medium should be more of a heat absorbent than a lubricant is further borne out by the widespread use of soluble cutting oils. The original soluble cutting lubricants consisted of mineral lard oils emulsified by mixing with weak borax or soda ash solutions. Later, paste compounds were developed and became widely accepted, due to the fact that they made better and more permanent emulsions than the mineral lard and alkali mixtures. Furthermore, in a cutting paste it was possible to put free alkalies as soda ash which would tend to correct hard water conditions in certain parts of the country where they existed, and the added alkali also tended to prevent rusting.

The outstanding disadvantages of metal cutting pastes are that they contain quantities of water and also are difficult to get into emulsion. Many of the older types required boiling before complete emulsification could be effected.

Later on there appeared soluble oils which when added to plain water would emulsify quickly and satisfactorily. The original types of soluble oil were made on the principle of holding mineral oil in emulsion with rosin soap dissolved in alcohol. This type of soluble oil, while still used to some extent, is rapidly waning, due to the fact that the alcohol evaporates and as a result free oil will separate on the top of the reservoir. Later, higher alcohols of non-volatile character were used in the making of these soluble oils, but had certain disadvantages in that they had a tendency to gum on the machines. Recently much attention has been given to the manufac-

ture of soluble oils. In looking over the field of products now being offered to the trade we find some with sulphonated fatty bases, most of which are made by digesting sulphuric acid with a fatty oil, washing out the excess, neutralizing and then adding mineral oil. This type of soluble oil makes a white emulsion, but usually does not have any properties of rust prevention nor the permanence and dependability of a soluble oil which are outstanding requisites.

Other types examined were made from salts recovered by treating sludges that occur in the refining of mineral oils. The particular disadvantage of this type of soluble oil is that it does not wet out the metal and does not withstand extreme water dilutions without separating and producing rust.

The last word in soluble cutting oils consists of a new type of phenol base combined with a suitable selected mineral oil of the proper gravity and viscosity. This type of product when mixed with water in any proportion makes a transparent solution. The fact that it makes a clear solution with water indicates the very fine dispersion of the oil globules in solution.

Now this is something that has really only been studied seriously recently, and you fellows in your electroplating jobs, I know that it is necessary that you get chemically clean surfaces and so on, and this new theory I think would be a good thing for you to understand. (Goes to blackboard.) By wetting out a piece of metal, is meant this:— For instance, if you have a soluble oil, and here is a piece of metal, the soluble of the older type, in solution, would show globules like this: (Draws large globules of oil around the metal, not quite touching.) Now, to wet out this metal surface, a soluble oil emulsion should combine with that metal surface. Any soluble oil or compound, that won't wet out, has a tendency, these oil globules, to hit on the metal surface and bounce back again; instead of combining there, they combine with one another. Whereas, with the new type of cutting oil, and also products that are used for drawing and so on, that wet out, the divisibility of the oil in suspension is very much more finely dispersed, and it will attach itself to the metal surface uniformly and evenly, without leaving any portions in between untouched by the oil or paste. (Draws diagram showing fine globules of oil closely packed on the metal surface.)

Now that has a bearing in your particular angle, in this way. If a product that is used for rust prevention, soluble oils, as some of them are, is made on the older type, where the oil globules are big

and they don't wet out or attach themselves to the metal, in between those globules are spaces that have no oil on them, and as a result they rust as soon as the water dries out. But with the newer type, those types that wet out the metal surface, there is absolutely no space whatsoever between the oil globules that is not thoroughly coated.

Where the maximum dilution of the old type soluble oil or paste would be 20 parts of water to 1 part oil, with the new type of product dilutions for the same operation could easily go 40 to 1 without any danger of rusting. The simple logic applied to this other than highly technical information shows that if you mix a poor soluble oil 20 to 1 and half the oil separates to the top, you have actually a 40 to 1 mixture remaining in the emulsion. Therefore, inasmuch as the newer type soluble oil does not separate under any condition, the first dilution equals the ultimate dilution of the old type soluble oil after running two or three hours. Furthermore, new scientific principles investigated in the soluble oil field show that a soluble oil should wet out the metal being cut instantly. By wetting out I mean reducing the surface tension in order that the emulsion will actually combine with the outer surface of the metal being cut.

The recognition of this chemical principle undoubtedly has much to do with the improved performance of the newer type oils. Furthermore, the phenol base soluble oils do not form curds or insoluble soaps with water having abnormal hardness, which is the same as saying water containing larger quantities of lime and magnesium salts. One part of lime will break down seven parts of a soap, and as all of the older type soluble oils were of soap bases they were subject to this disintegration, but the newer types are not subject to this same ratio of destruction by these chemicals.

Another improvement to be had in this new soluble oil is that they are actually aseptic in themselves, due to the fact that they have phenol bases and as a result are not carriers of bacteria as was the case of the ordinary soluble oil. All the types of germs that flourished in the older soluble oil emulsions are instantly killed in the new type, and the best proof of this is the reduction of skin eruptions among the operators and the fact that the new oil does not become foul smelling to such an extent that it must be thrown out before its life has been completed. There are any number of concerns who would have to throw out their soluble oil emulsions

over the week-end, due to the fact that on Monday morning the odor of the solution would be such that the men could not bear it. This is practically eliminated with the newer oils.

With reference to rusting of soluble oils, I wish to add that this has been given considerable scientific study, and we find that the type of water used, type of metal being cut, humidity, operations, storage, etc., subsequent to the cutting job have much to do with rust. There are certain metals that rust so fast that soluble oils of any kind are out of the question. Other metals that would rust after using soluble oils can be prevented from rusting by going into cleaner baths or by being subjected to heats or coating with rust preventives, etc.

The newer type soluble oil is a better rust preventive than the older types, due to the fine oil dispersion that they make and their ability to adhere constantly to the metal surface. This gives a uniform coating of a very fine oil film on the metal, whereas with the older soluble oil I pointed out the inability to combine with the metal surface and natural characteristic of the dispersed oil joining to make larger globules always left the metal protected where those oil globules deposited themselves, but was rusted considerably between them. Furthermore, the viscosity of the newer type soluble oils has much to do with the problem of rust prevention.

So much for the cutting oils.

Now let us consider drawing or forming lubricants.

The first lubricants used to prevent metal-to-metal contact in forming operations were lard oil and tallow, either separately or combined. This combination, we must admit, is very good even to this day. It is good because it does prevent metal-to-metal contact on certain types of work, and being all saponifiable it is very easily removed in the cleaning operation.

However, the old staples are also falling by the way since this end of the business has come under scientific surveillance. We know that colloids of various characters are better drawing lubricants than either straight tallow or lard oil. I could mention numerous operations that cannot be done nearly as well with straight tallow as can be done with a combination of tallow and flour. The introduction of the flour, which is a colloid, has a certain cushioning effect that actually makes a decided difference.

The nearest non-technical way that I know to show you how a colloid acts is to take chemically pure gelatin, which you may know

as jello, and if you would mix a small amount of this colloid in water and let it rest overnight you would find that instead of the jello dissolving in the water, the water is actually absorbed by the jello.

There is much to be learned by all chemists in the field of colloid chemistry, but this much we can say: that when used in a drawing medium it offers no resistance to subsequent cleaning operations and imparts decided advantages to the drawing medium in which it is used.

There are other colloidal type fat products that we have learned how to handle and convert into a semi-pasty form so that when they come to the user they can be applied either in the form in which they are received for unusually difficult operations or they can be diluted with water for the lighter jobs to the maximum proportion that will continue to give satisfactory results. In this manner the drawing lubricant is more on the order of a base.

As I have pointed out in the discussion under cutting oil that sulphur and products with ability to absorb and radiate heat are widely used in cutting oils, this chemical acts in exactly the same manner when combined with a drawing lubricant. Certain types of blanking and stamping jobs require combinations of heat-absorbing chemicals, pigment cushioning agents, soluble fats and colloids. There are still some drawing lubricants on the market that are difficult to prepare before using, some that do not spread far enough on the metal, some that contain abrasives and others that are resistant to cleaning operations, but I can safely say that they are rapidly disappearing. The specialty houses with highly trained technical forces are making too much progress for the fellow who is satisfied to rest with the old-type drawing mediums. It is no trick at all to call upon a house that specializes in this field, tell them the type of metal you are drawing, the gauge of the metal, depth of the draw, diameter of the wall and your present method of applying the drawing medium, and without any hesitation they could supply you with a product that would meet all of your requirements on the first selection.

The removal of drawing compounds is a separate discussion which will be tied in at some later date in a talk on metal cleaning specialties.

Now, in this field of fatty oils, I note that chromium is coming into widespread use for rust prevention and presenting a bright

surface, and so on, and it might interest you to know that about fifteen years ago we in the specialty oil field found that the introduction of a half of one per cent of sodium chromate, with any fat, or a half of one per cent solution of sodium chromate in water, was sufficient to prevent any metal from rusting. The old theory of rust prevention used to consist of taking any oil and coating the metal with it, and the theory of preventing the rust by using a product of that type consisted of excluding the oxygen of the air, therefore preventing the iron oxide which is rust. But the new type rust preventatives, embodying the use of chromates that you use, are even better than the old type, and they work on an even different principle. In addition to excluding the oxygen from the air, they also have a tendency to prevent any oxidization that might take place underneath the oil film. And so there are soluble products made that can be used for preventing rust, either for interdepartmental work or for use on products that are to be shipped through torrid zones, products that are not to be used or unpacked for three or six months, or a year. And I thought you would be interested to know that the chromium principle of rust prevention was used in the oil industry fifteen years ago.

PRESIDENT LUNBECK: This has been an interesting talk and in various ways is of quite some value to the plater, because if he knows something of the compositions of the lubricants which are used on the work before he receives it to be finished he will be better able to judge the ways and means in which he is to clean this work for plating. If there is anyone who wants to ask a question in reference to this talk, the paper is up for discussion.

As there are no questions, we will pass on to the Question Box.

I find here a question on plating of small screw and pins. These small parts are to be chromium plated without racking or wiring. Can they be chromium plated in a barrel or basket in quantity successfully?

Answer—The nickel finish you have there is not good enough in the first place for a good chromium finish. If this finish is good enough with chromium on it, you can do them in a basket.

The basket should be made with either bakelite or glass sides, and not more than one inch deep, the bottom to be made of wire screen of proper mesh, and the leads to the basket should be well insulated from the contact up out of the solution.

Our tank was deep, and instead of putting the basket in the solution as you ordinarily do with the basket near the top of the solution, we ran the basket almost to the bottom of the tank, and so the screws would plate in from the top, and that is what we mean by cheap screws, one where a tumble finish was good enough in the nickel; but on screws where we had a buffed nickel finish to plate chromium on we had a brass or copper pan made about 10 inches square, with holes of the proper size, and we set the screws in these

holes, and hung this pan in the tank in a perpendicular position, and in this way we got every screw perfect.

JOSEPH E. UNDERWOOD, *Secretary.*

HARTFORD-CONNECTICUT VALLEY BRANCH

The Hartford-Connecticut Valley Branch held its regular meeting on Monday evening, March 30, at the Chamber of Commerce Rooms, Hartford, Conn.

The meeting was called to order at 8:15 p.m. with President Beloin in the chair. Minutes of the previous meeting were read and approved. Communications were read and placed on file. No bills were presented. President Beloin commented on our good showing at the Bridgeport educational session and banquet.

Mr. MacDermid then introduced Mr. Henry J. Fischbeck, chief chemist and metallurgist for the Pratt and Whitney Airplane Co., of Hartford, Conn.

Mr. Fischbeck gave us one of the most interesting talks of the year. He gave a brief history of aeroplane advancement in this country since the work done by the Wright Bros. in 1902. He described the advance made in motor construction and the part played by the electroplater in this advancement. He exhibited many parts of the motor, describing each part, what it was made of, how and why. He showed the application of the use of cadmium, chromium and copper plating on the motor and plane parts. He also explained the rigid tests and inspection given each part.

Mr. Fischbeck's talk was certainly interesting and instructive, and in conclusion he was given a rising vote of thanks.

The meeting was attended by twenty members and visitors, and was adjourned at 10:15 p.m.

V. E. GRANT, *Secretary.*

CHICAGO BRANCH

The regular monthly meeting of Chicago Branch, A. E. S., was held Saturday, April 11, 1931, at the Atlantic Hotel.

The meeting was called to order with Past President F. J. Hanlon presiding. President S. J. C. Trapp and Vice-President J. J. Witte were absent; all other officers present.

Mr. Harold Faint gave the first of a series of lectures. These lectures will be given each meeting night at 7 o'clock p.m. sharp. Members should make an effort to get here early, as those who come late are missing some very valuable information.

The officers of Chicago Branch wish to call your attention to the call for exhibits to be shown at the annual convention which is to be held at Rochester, N.Y., June 29 to July 2, 1931.

These exhibits are one of the high lights of the convention, and all members who can are urged to make up samples and give all possible information about them. Prizes will be awarded for the best exhibits, and Chicago Branch is anxious to be well represented.

After the regular order of business had been transacted, the meeting was turned over to the librarian, Mr. O. E. Servis, and the following questions were found in the box:

Question—What is considered a good salt spray test for nickel and chrome plated die castings?

Answer—24 hours. 20% sodium chloride is standard.

Question—How can you explain the difference in density between the top and bottom of the tank?

Answer—There was considerable discussion on this subject. The general opinion was not enough agitation.

J. C. KRETSCHMER, *Secretary.*

PROVIDENCE-ATTLEBORO

Meeting April 3, 1931, 44 Washington Street. Dr. L. C. Pan was the speaker.

The Doctor arrived in time for a few introductions before the meeting started. Mr. L. E. Briggs, works manager of the Gorham Co., kindly consented to act as master of ceremonies, and introducing Dr. Pan he gave a brief prelude in which he stated that the Doctor was to talk on electroplating as a science, rather than an empirical trade.

Dr. Pan announced that he would talk on the topic, "Things We Learn in the Laboratory."

The Doctor, after briefly referring to the class in electroplating conducted by him at the College of the City of New York, called attention to the past condition of the Society by quoting Dan Wittig's slogan: "We had no definite program." "Dan" used this slogan very effectively at the last convention in relating the history of the chemistry class in Milwaukee.

The Doctor, in touching on the present activities of the Society, in class work, stressed the point that it was not so important that the plater is able to analyze his solutions accurately, but rather that he have the ability to calculate from the analyses just how much, and what, ingredients were necessary to keep the solutions in proper working condition, and also that he have an outline or framework of what knowledge was necessary for him so that he could intelligently make use of the scientific articles appearing from time to time in the trade papers and scientific papers.

The Doctor stated that it was also important for the plater to have his own private laboratory so that he could work out ideas for himself in his own home if necessary.

At the conclusion of the talk Mr. Briggs announced that Dr. Pan would answer questions on plating, and then we had a good half hour of questions and answers from various angles; and, in replying, Dr. Pan indicated that he had his subject well in hand.

The questions were mostly in relation to chromium plating, Dr. Pan stating that he was not familiar with rhodium plating.

Mr. Briggs called for a rising vote of thanks, and the response was unanimous.

There were 40 present besides the speaker.

JOHN ANDREW, *Secretary.*

CLEVELAND BRANCH

The regular monthly meeting of the Cleveland Branch was held on Saturday evening, April 4—President E. Steen Thompson presiding.

The minutes of the previous meeting were approved as read. The application of Mr. C. M. Hoff was read and turned over to the Board of Managers. Letters were read from the Convention Education and Exhibit Committees.

The business of the meeting being concluded, the meeting was turned over to our Librarian, who read a paper on the "Protective Value of a Copper Strike."

After a short discussion, a motion to adjourn was carried at 10 p.m.

PAUL STAMM, *Secretary.*

ST. LOUIS BRANCH

Regular meeting of the St. Louis Branch, A. E. S., was held at the La Salco Co. Plant, April 10, 1931.

Minutes of the previous meeting were read and approved.

The roll-call of officers showed one absent.

Letter was read from Milwaukee Branch, inviting the members to attend a stag party. (Thank you; hope you have a good time.)

Question was asked how to polish aluminum with a flexible shaft, the easiest way, as the piece is rather large. No further business, meeting was turned over to Mr. H. H. Williams, librarian, who in turn called on Dr. Stout of Washington University.

Dr. Stout gave a demonstration on how to determine the amount of silver in a silver solution, and answered all questions put to him in a very clear way.

Next meeting will be held April 24 at the same place, and Dr. Stout will work on cyanide in the zinc and silver bath.

Meeting then adjourned with 17 members present.

CHAS. T. MCGINLEY, *Secretary.*

MILWAUKEE BRANCH

Milwaukee Branch's educational session and smoker held Saturday, April 18, was a decided success. This was held in place of the annual banquet.

HEAR YE! HEAR YE!

Lest Ye Forget!

YOUR PRESENCE REQUESTED
AT THE
COMING CONVENTION
OF THE

American Electro-Platers Society

TO BE HELD AT

Seneca Hotel

ROCHESTER, NEW YORK

"THE CONVENTION CITY"

June 29-30 — July 1-2, 1931

PAPERS: "Good" and "Plentiful."

EXHIBITS: We Solicit.

ENTERTAINMENT: We Aim to Please.

BRING THE LADIES
REMEMBER THE DATES

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WALLACE A. KEEFE, 144 Camp Street, Jamestown, N. Y.....Rochester
EDWARD E. KLATZKE, 8069 Marion Street, Detroit, Mich.....Detroit
ARTHUR SUTCLIFFE, 2574 Pennsylvania Avenue, Detroit, Mich.....Detroit
EARL D. LAMAR, 131 Mission St., San Francisco, Cal.....San Francisco
FRANK CELENTINO, 66 Oliver St., San Francisco, Cal.....San Francisco
LAWRENCE MILLER, 839 32nd Street, Oakland, Cal.....San Francisco
W. S. HATHORNE, 1031 Pacific Ave.....Waukegan, Ill., Associate
L. A. KAMPELMAN, 633 Deming Place.....Chicago, Ill., Associate

ELECTIONS

EDWARD E. KLATZKE, 8069 Marion Street, Detroit, Mich.....Detroit
ARTHUR SUTCLIFFE, 2574 Pennsylvania Ave., Detroit, Mich.....Detroit
EARL D. LAMAR, 131 Mission St., San Francisco, Cal..... San Francisco
FRANK CELENTINO, 66 Oliver St., San Francisco, Cal.....San Francisco
LAWRENCE MILLER, 839 32nd Street, Oakland, Cal.....San Francisco
JOHN A. BAUER, 106 Liberty Ave., Pittsburgh, Pa. (Assoc.).....Pittsburgh
GEO. B. SORNSON, 106 Liberty Ave., Pittsburgh, Pa. (Assoc.).....Pittsburgh
FRANK BAULE, 152 Bleecker St., Newark, N. J.....Newark
MICHAEL ARON, 425 Central Ave., Orange, N. J. (Assoc.).....Newark

RESIGNATIONS

EMIL G. NORDBLOOM, 36 Grant Street, Jamestown, N. Y.....Rochester
F. W. LAFSER, 5016 Alaska Ave., St. Louis, Mo.....St Louis

SUSPENSIONS

FRANK BEESON, c/o Quality Plating Wks., Evansville, Ind.....St. Louis
AUG. COERVEN, 4218 Lee Avenue, St. Louis, Mo.....St. Louis
REES J. RICKETS, 1513 Chestnut St., St. Louis, Mo.....St. Louis
PAUL DOWNS, 17126 Goddard Avenue, Detroit, Mich.....Detroit

TRANSFERS

Jos. LEVOY to San Francisco Branch from.....St. Louis
R. C. LEDIG, to Rochester Branch.....Philadelphia

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BUREAU OF EDUCATION

Chairman, MR. ALBERT HIRSCH,.....1945 Airdrie St., Philadelphia

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Cleveland Branch.....J. C. SINGLER
Hartford-Connecticut Valley.....TENNANT ELWIN, FRANK J. CLARK
Worcester Branch.....M. H. FROMMANN
Toronto Branch.....C. KEMESH

Other Branch Representatives will be printed as received.

ANDERSON BRANCH

Meets first Monday of every month at 7:30 p.m. at the Anderson Indiana Y. M. C. A. R. M. Wagner, Secretary-Treasurer, 28 W. 12th St., Anderson, Indiana.

BALTIMORE-WASHINGTON

Meets in Enoch Pratt Library, Calhoun and Hollis Sts., Irvin H. Hahn, Secretary, 207 S. Sharp St., Baltimore, Maryland.

BOSTON

Meets at American House, Boston, Mass. First Thursday each month. Secretary A. W. Garrett, 45 King St., Dorchester, Mass.

BRIDGEPORT

Meets first and third Friday of each month at Chamber of Commerce Rooms, Stratfield Hotel. Secretary, T. H. Chamberlain, 859 Orange St., New Haven, Conn.

CHICAGO

Meets second Saturday of each month, at 8 p. m., Atlantic Hotel, 316 S. Clark St., Secretary, J. C. Kretschmer, 1914 Warner Ave.

CINCINNATI

Meets every Thursday, 7:30 p. m., at Vocational Training School, Spring and Liberty Sts. Secretary, Al Yeager, 2021 Sherman Ave., Norwood, Ohio.

CLEVELAND

Meets first Saturday of each month at Hotel Winton, Paul R. Stamm, Secretary, 947 Elbon Road, Cleveland Heights, Ohio.

DAYTON

Meets first Saturday of each month at the Y. M. C. A., Dayton, Ohio. Secretary, Robert G. Suman, 2734 Ridge Road, Dayton, Ohio.

DETROIT

Meets the first Friday of each month at the Hotel Statler, Louis II Room. Secretary, Chas. Phillips, 18431 Camden Ave., Detroit, Mich.

GRAND RAPIDS

Meets second Friday of each month at 522 Lake Michigan Drive, N. W. Secretary, Jacob Van Dyke, 1361 Union Ave., N. E., Grand Rapids, Mich.

HARTFORD-CONNECTICUT VALLEY

Meets fourth Monday in each month alternately at the Chamber of Commerce 815 Main St., Hartford and the Chamber of Commerce 134 Chestnut St., Springfield. Secretary Vernon Grant, 43 Putnam St., Bristol, Conn.

INDIANAPOLIS

Meets second Saturday of each month at Hotel Denison. Secretary, Louis Mertz, 1725 Union St., Indianapolis, Ind.

LOS ANGELES

Meets second Wednesday of each month at the Chamber of Commerce Bldg., 9th floor, 1151 S. Broadway. Secretary, M. D. Rynkofs, 1354 W. 25th St., Los Angeles, Calif.

MILWAUKEE

Meets second and fourth Thursdays of each month at Cor. 3rd and Highland Ave. J. N. Hock, 1239 W. 24th St., Milwaukee, Wis.

MONTREAL

Meets second and fourth Friday of each month at 1437 Aylmer St. Montreal, Quebec, Canada, where the Secy-Treas. Mr. Charles Doherty, can be found at any time.

NEWARK

Meets first and third Fridays of each month at Franklin Hall, 41 Franklin St., Newark, N. J., at 8 p. m. Secretary-Treasurer, Geo. Ruster, P. O. Box 201, Newark, N. J.

NEW YORK

Meets second and fourth Fridays of each month in the World Building, Park Row, New York City, N. Y. Secretary-Treasurer, J. E. Sterling, 2581 46th St., Astoria, L. I.

PHILADELPHIA

Meets first Friday of each month in the Harrison Laboratory Building, University of Pennsylvania, 34th and Spruce Sts. Secretary, J. E. Underwood, 327 N 10th St., Camden, N. J.

PITTSBURGH

Meets first Friday of each month at 8 p. m., at downtown branch, Y. M. C. A. Secretary, S. E. Hedden, 227 Fifth St., Aspinwall, Pa.

PROVIDENCE-ATTLEBORO

Meets first and third Thursday of each month at 44 Washington St., Prov. Engineers Rooms, Providence, R. I. Secretary, J. H. Andrews, 19 Rosedale St., Providence, R. I.

ROCHESTER

Meets third Friday of each month at Hotel Seneca. Secretary, Chas. Griffin, 24 Garson Ave., Rochester, N. Y.

SAN FRANCISCO BRANCH

Meets at Plaza Hotel, San Francisco. Secretary, H. W. McKibben, 310 Tehama St., San Francisco, Cal.

ST. LOUIS

Meets second Friday of each month at the Plant of the Lasalco Co., 2828 LaSalle St. Secretary, C. T. McGinley, 3214 Fairham Ave., University City, Mo.

TOLEDO

Meets first Thursday of each month at Toledo Secor Hotel, Cherry and Page Sts. James M. Lee, Secretary, Barker Street, Fremont, Ohio.

TORONTO

Meets fourth Monday of each month at Canadian Foresters' Hall, 22 College St., Room No. 2. Secretary, H. W. Graham, 102 Robina Ave., Toronto, Canada.

WATERBURY

Meets second Friday of the month at Engineers Hall, No. 11 East Main Street. Wm. F. Guilfoile, secretary, P. O. Box 961, Waterbury, Conn.

WORCESTER

Meets Directors' Room, Chamber of Commerce, Worcester, Mass. Roger H. Bryant, Secretary, 94 Grove St., Worcester, Mass.